RECLAMATION
Managing Water in the West

Draft Environmental Impact Statement

Navajo Generating Station-Kayenta Mine Complex Project

Volume 5 – Appendices 3RA through 4A

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Appendix 3RA

Summary of Risk Assessments Conducted in Support of the NGS-KMC EIS

This page intentionally left blank

Contents

1.0 Ecological Risk Assessment 3RA-1

1.1 ERA Objectives and Process....................3RA-3

1.2 Risk Assessment Study Areas 3RA-4

1.3 Risk Assessment Datasets....................3RA-8

1.4 Ecological Risk Assessment Process Overview....................3RA-10

1.4.1 Key Exposure and Toxicity Assumptions Applied for the Ecological Risk Assessments....................3RA-11

1.4.2 Key Concepts for Risk Estimation and Description 3RA-15

1.4.3 Ecological Risk Assessment Results 3RA-17

1.4.4 Key Uncertainties....................3RA-26

1.5 References 3RA-29

List of Tables

Table 3RA-1 Chronology of Key Milestones and Documents in Development of the Ecological and Human Health Risk Assessments

Table 3RA-2 Summary of Chemicals of Potential Ecological Concern for NGS-KMC Risk Assessments

Table 3RA-3 Representative Species Used in the Ecological Risk Assessments

Table 3RA-4 Summary of Risk to the Soil Community and Associated Wildlife in the NGS Near-Field Study Area

Table 3RA-5 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS Near-Field Study Area

Table 3RA-6 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS Northeast Gap Region Study Area

Table 3RA-7 Summary of Risk to the Aquatic and Benthic Community and Wildlife in the NGS Southwest Gap Region Study Area

Table 3RA-8 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS San Juan River Study Area

Table 3RA-9 Summary of Risk to the Soil Community, Aquatic and Benthic Community and Associated Wildlife in the Kayenta Mine Complex Study Area

Table 3RA-10 Common Uncertainties Associated with Ecological Risk Assessment

List of Figures

Figure 3RA-1 Navajo Generating Station Near-Field Ecological Risk Assessment Process Summary

Figure 3RA-2 San Juan River Ecological Risk Assessment Process Summary

Figure 3RA-3 Gap Regions Ecological Risk Assessment Process Summary

Figur e 3RA-4 Kayenta Mine Ecological Risk Assessm ent Process Summar y

1.0 Ecological Risk Assessment

Four ecological risk assessments were conducted in support of the Navajo Generating Station (NGS) Environmental Impact Statement (EIS). These risk assessments were conducted by Ramboll Environ under contract to Salt River Project (SRP) to identify potential impacts to the environment from future operations related to the NGS and the proposed Kayenta Mine Complex (KMC) (Ramboll Environ 2016a,b,c,d). Risk assessment represents one component in the overall EIS analysis to estimate the impacts on the environment and is focused specifically on identifying the potential for adverse effects to ecological endpoints (i.e., plants and animals) resulting from exposure to project-related chemicals. This appendix presents an overview of the process and key supporting information used to develop the ecological risk assessments (ERAs) completed by Ramboll Environ. In addition, an overview summary of ERA results and conclusions is provided. Given the number and complexity of the ERAs conducted, the overall intent of this appendix is to serve as a summary source for key risk-related information used within various biological resource sections of the EIS. Please see the Ramboll Environ ERAs (Ramboll Environ 2016a,b,c,d) for full details including methods and results.

The original Statement of Work specified that an ecological risk assessment be conducted as part of the EIS process in accordance with the U.S. Environmental Protection Agency (USEPA) Ecological Risk Assessment Guidance (1997, 1998, 1999, and 2001). The original Statement of Work was modified to include the development of Risk Assessment Study Plans to further guide the risk assessment process. The Risk Assessment Study Plans have undergone multiple agency review (**Table 3RA-1**) and include:

- Near-field Ecological Risk Assessment Study Plan for Navajo Generating Station.
- Summary of Approach to Assess NGS Gap Regions.
- San Juan River Ecological Risk Assessment Study Plan (Environ 2015).
- Kayenta Mine Complex Ecological Risk Assessment Study Plan.

Ramboll Environ conducted the four ERAs for the project to evaluate the potential for adverse effects to representative terrestrial receptors (wildlife and soil communities), aquatic-oriented wildlife, and aquatic and benthic communities observed or expected to occur locally or regionally with the potential to be affected by baseline or proposed future operation of NGS and the proposed Kayenta Mine Complex. In these ERAs, “baseline” refers to the existing environmental conditions as of December 22, 2019, which includes “natural environmental conditions and the pollutants produced by past NGS operations and other emission sources that have accumulated in the environment in the study area” (Ramboll Environ 2016a). The proposed “future operations” refers to projected impacts from operation of the facilities for the 25-year period of the EIS Proposed Action (2020 through 2044) as well as other cumulative sources (OCS). This evaluation is carried through to 2074 to capture the time period between the closure of NGS and the movement of constituents of potential ecological concern (COPECs) through the watershed and food web. The four assessments are:

- **NGS Near-field ERA** – The NGS Near-field ERA (EIS **Figure 3.0-5**) evaluated existing baseline conditions and potential future environmental conditions in the vicinity of NGS (Ramboll Environ 2016a). Baseline conditions were estimated from soil, surface water and sediment data collected in summer 2014 within the 20-kilometer (km) study area defined for the ERA. These baseline data, especially soil data, are considered representative of past cumulative emission/deposition from all local, regional and global sources. The methods and results of this sampling event were reported in the NGS Near-field Sampling Investigation Report (Ramboll Environ 2016f) to form the basis for defining baseline conditions in this study area. In addition, recent literature data were considered in establishing baseline tissue concentrations for fish species that occur within the study area (Ramboll Environ 2016a). These baseline data, along with future NGS emissions and other cumulative emission sources, were used to specifically evaluate the potential ecological risk in terrestrial and aquatic environments from exposure to chemicals present under baseline conditions and under anticipated future operations for NGS and other cumulative emission scenarios. Future emissions data for NGS were developed using AERMOD air dispersion model (Ramboll Environ 2016a) and OCS results were obtained from the Electric Power Research Institute (EPRI) Study (EPRI 2016), each described in greater detail subsequently.

- **San Juan River ERA** – The San Juan River ERA (EIS **Figure 3.0-6**) evaluated existing baseline conditions and potential future environmental conditions in the San Juan River using results from the EPRI study (EPRI 2016) study to assess the potential future effects to receptors. EPRI (2016) integrated a multi-scaled air quality model to estimate the contributions of arsenic, mercury, and selenium to the San Juan River watershed from global, regional (western U.S.), and local sources; specifically isolating and analyzing the deposition from NGS, the Four Corners Power Plant, and the San Juan Generating Station. Baseline conditions in the San Juan River were based on surface water, sediment, and fish tissue data obtained from the literature (Ramboll Environ 2016b). The regional air model and a watershed biogeochemical cycling and aquatic biota bioaccumulation model were used to calculate the concentration of arsenic, selenium, and mercury over space and time in the San Juan River basin. The regional extent of the study extended downstream to the San Juan arm of Lake Powell. The ERA identified the potential for adverse effects to aquatic and aquatic-oriented receptors. The EPRI study also estimated fish tissue concentrations of mercury in federally endangered fish species (Colorado pikeminnow and razorback sucker) over time to 2074. As noted, the EPRI study (2016) was used in the ERA and also in independent analysis in cooperation with the U.S. Fish and Wildlife Service (USFWS) to evaluate the impacts of the project.
- **Gap Regions ERA** – The Gap Regions ERA (Ramboll Environ 2016c) (EIS **Figure 3.0-7**) evaluated existing baseline conditions and potential future environmental conditions in areas not specifically addressed by the NGS Near-field ERA or San Juan River ERA. Baseline conditions in the Gap Regions were estimated from surface water, sediment, and fish tissue data obtained from the literature, and future conditions were based on emission/deposition data from the EPRI (2016) study (Ramboll Environ 2016c). The ERA evaluated aquatic and aquatic-oriented ecological receptors only, with a special focus on special status species occurring in the Northeast and Southwest Gap Regions described in detail in Chapter 3.0.
- **Kayenta Mine ERA** – The proposed KMC ERA (EIS **Figure 3.0-8**) evaluated existing baseline conditions and potential future environmental conditions in the vicinity of the proposed KMC (Ramboll Environ 2016d). Baseline conditions were estimated from soil, surface water and sediment data collected in summer 2014 within the study area defined for the ERA. These baseline data, especially soil data, are considered representative of past cumulative emission/deposition from all potential sources, including local ground-level emissions (fugitive dust), and regional and global emission/deposition associated with coal combustion. The methods and results of this sampling event were reported in the proposed KMC Sampling Investigation Report (Ramboll Environ 2016g) and, along with surface water monitoring data provided by Peabody Western Coal Company, form the basis to define baseline conditions in this study area. These baseline data, along with ground-level dust emissions and other cumulative emission sources, were used to specifically evaluate the potential ecological risk in terrestrial and aquatic environments from exposure to chemicals present under baseline conditions, and under anticipated future NGS and other cumulative emission scenarios (EPRI 2016; MMA 2015).

The approach and methods used for evaluating the potential impacts of the Proposed Action and associated NGS and KMC operation scenarios is consistent with the following key guidance documents:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA 1997);
- Guidelines for Ecological Risk Assessment (USEPA 1998);
- Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (USEPA 1999); and
- The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments (USEPA 2001).

These planning and subsequent risk assessment documents were developed with extensive input and review from the Bureau of Reclamation (Reclamation); key cooperating agencies (Office of Surface Mining Reclamation and Enforcement [OSMRE] and Bureau of Indian Affairs [BIA]); other cooperating agencies and ERA subgroup members including the USFWS, National Park Service (NPS), and others. A chronology of key risk assessment documents and decisions in development of these ERAs is provided in **Table 3RA-1**.

1.1 ERA Objectives and Process

The purpose of the ecological analysis was to evaluate whether significant risks to aquatic and terrestrial wildlife, particularly special status species, are occurring due to exposure of COPECs from NGS or from COPECs associated with KMC mining activities. Ecologically significant impacts to wildlife from a regulatory perspective are those that will occur on a scale that could impact populations, communities, and ecosystems of wildlife and the habitat that supports wildlife (USEPA 1998, 1997a, 1994). Special regulatory consideration is given to individual organisms of threatened and endangered species populations since these individuals comprise a greater percentage of the small threatened and endangered populations (USEPA 1998,1997a).

These assessments compiled and assimilated data collected during past and recent investigations, and evaluated these data to develop a "snapshot" of potential risks associated with baseline conditions and potential future operation conditions assuming continued operations of NGS and the proposed KMC (from 2020 through 2044). The results of the ERAs help determine what, if any, risks might exist and provide information to determine if actions should be considered to reduce or eliminate these risks. The risk assessment outcome is intended to supplement the Affected Environment discussion in the EIS and provide information for Environmental Consequences related to future operations of NGS and the proposed KMC.

The following sections summarize the development and outcome of the ecological risk assessments conducted in support of the EIS; to capture commonality in the approaches and key assumptions used for each ERA; and then specifically to discuss data sources, key assumptions, and other elements important to each ERA. Please see the individual ERA documents for full detail regarding approach, methods, results and conclusions.

The risk assessments follow the procedures and protocols set forth in federal risk assessment guidance and each was conducted using the same basic steps. The key components of risk assessment include: Problem Formulation, Analysis (Exposure Assessment and Toxicity Assessment), Risk Characterization and Uncertainty Analysis. These components are summarized below and greater detail is presented in Section 3.0.4.

- **Problem Formulation** –the initial planning phase includes characterizing the environmental setting, identifying chemicals of potential ecological concern (COPECs), defining representative ecological receptors and special-status species, defining assessment and measurement endpoints, and integrating these elements into a conceptual site model (CSM) to provide a conceptual depiction ecological receptor exposure to serve as a guide for the overall ERA process.

- **Analysis (Exposure/Toxicity Assessments)** – the analysis phase of the ERA process includes the Exposure Assessment and Toxicity Assessment, which provide the quantitative exposure and toxicity parameters, respectively, needed to estimate risk. The Exposure Assessment includes the methods for estimation of exposure point concentrations (EPCs) and the receptor-specific exposures. The Toxicity Assessment provides a review of chemical-specific toxicity information available from peer-reviewed literature and state/federal sources and identifies the applicable toxicity metrics for assessing risk.
- **Risk Characterization/Uncertainty Analysis** – the risk characterization integrates the problem formulation, exposure assessment and toxicity assessment to provide quantitative estimates of risk represented by the hazard quotient (HQ). The uncertainty analysis discusses the uncertainties inherent to all risk assessments and site-specific uncertainties to provide context to the risk estimates.

In accordance with USEPA guidance (USEPA 2001, 1999, 1998, 1997), the ERA process is iterative. Each iteration or tier allows for the introduction of additional site-specific information and/or methods to provide a more specific and realistic estimate of risk. The initial or screening level evaluation is by default very conservative and uses maximum exposure scenarios and conservative toxicity data to estimate risk. For those receptor-COPEC pairings indicating potential for risk in the initial screening level evaluation (i.e., those pairings that cannot be eliminated), an additional tier(s) is conducted to develop risk estimates with site-specific relevance more representative of the exposure setting. The “refined” risk assessment scenario is intended to limit the uncertainties associated with risk estimates and provide a point of departure for additional risk assessment tiers or consideration by risk managers for decision making.

A summary of the overall ERA process specific to each risk assessment is provided for reference in **Figure 3RA-1** (NGS Near-field), **Figure 3RA-2** (San Juan River), **Figure 3RA-3** (NGS Gap Region), and **Figure 3RA-4** (proposed KMC). The following sections briefly outline the risk assessment study areas for each ERA followed by a summary review of key assumptions and the outcome of each ERA step.

1.2 Risk Assessment Study Areas

The study areas for the ecological (and human health risk assessments) were defined in consultation with federal agencies including Reclamation, OSMRE, BIA, USFWS, NPS and others through development and review of the risk assessment planning documents and risk assessment reports (Ramboll Environ 2016a,b,c,d). The primary risk assessment study areas include the NGS Near-field and Kayenta Mine (evaluated for human health and ecological risk); and the San Juan River and NGS Gap Regions (evaluated for ecological risk only). Each of these areas is depicted in **Figure 3.0-5, Figure 3.0-6, Figure 3.0-7**, and **Figure 3.0-8** of the EIS, respectively, and described below.

<u>Near-field ERA Study Area</u>

The NGS Near-field ERA evaluated a suite of target chemical constituents (COPECs) including inorganic chemicals (including arsenic, mercury, and selenium) and organic chemicals (e.g., dioxins/furans and polycyclic aromatic hydrocarbons [PAHs]). Among those COPECs present in NGS stack emissions, selenium was identified as having the highest rate of deposition (propensity to fall out of the atmosphere) and potential for ecological effects than any other COPEC (Ramboll Environ 2016a). Selenium was therefore chosen to represent all other COPECs for defining the near-field study area. A conservative soil deposition threshold, or soil concentration at or below which no adverse effects to human health or the environment is expected, was developed based on NGS stack/emission parameters and meteorological considerations using the AERMOD atmospheric dispersion modeling system (Ramboll Environ 2016a).

A protective soil deposition rate of 52 micrograms of selenium per square meter of soil per year was estimated and used to determine the study area boundary. This rate is protective of ecological and human health receptors exposed to selenium deposited to soil, and receptors present in areas where the deposition rate is lower than this threshold (i.e., further away from stack emissions). Therefore, the study area was determined to be the area within which there is a potential to exceed the threshold assuming continued operation of NGS from 2019 through 2044 (Environ 2014a,b). To ensure that human health and the environment are protected, the defined deposition threshold was conservatively based on 10 percent of the lowest selenium ecological soil screening level (10 percent of 0.52 milligrams selenium per kilogram soil or 0.052), an amount that is protective of the most sensitive ecological receptor reported in USEPA Guidance (USEPA 2007). This threshold also is protective of human health receptors that have an USEPA Regional Screening Level (RSL) for selenium of 39 milligrams selenium per kilogram soil (USEPA 2015). This level is protective of residential exposure to soil, and is greater than 100-times higher (less conservative) than the ecological soil screening level. The results indicated the deposition area (i.e., where selenium deposition exceeds 52 micrograms of selenium per square meter of soil per year) to be within a 16-km radius of the source. The 16-km radius was conservatively rounded upward to a 20-km radius, which is defined as the NGS Near-field study area (**Figure 3.0-5** of the EIS).

The 20-km extent of the study area was subsequently verified by consideration of background soil data collected within a 20-km radius of NGS (Ramboll Environ 2016) in combination with the AERMOD data deposition profile for selenium (Ramboll Environ 2016a). Inclusion of the selenium soil background concentration (representative of human-caused/natural existing conditions) to develop the threshold level addresses the incremental (annual) deposition of selenium to the environment while also conservatively accounting for the contribution from background conditions. Based on the AERMOD data deposition profile for selenium reported by Environ (2014a) and with consideration of selenium soil background (0.195 milligram/kilogram [mg/kg]) reported in the NGS Sampling Investigation Report (Ramboll Environ 2016e), the selenium deposition threshold protective of ecological and human health receptors was 325 micrograms selenium per square meter soil per year. This level was determined without the conservative adjustment by 10 percent because it considered both site-specific AERMOD data (Ramboll Environ 2016a) and background soil conditions. The preliminary study area extent (20-km radius from NGS) originally applied, used a screening air model without background soil consideration. These results indicated the deposition area to be at about a 3-km radius from the NGS stacks, well within a 20-km radius study area defined for the NGS.

The modeling objective using AERMOD was to estimate annual deposition of the COPECs, which in turn were used for modeling soil, surface water and sediment concentrations using IRAP-h View (USEPA 2005). To this end, atmospheric deposition was simulated for the NGS under several potential emission scenarios. Three primary air dispersion and deposition modeling simulations were conducted:

- 3-Unit Operation – characterized by 2,250-megawatt (MW) NGS operations, with all 3 NGS units operating (referred to as the “B2 Scenario” in the ERA reports and represents the maximum amount of future emissions under the proposed action);
- 2-Unit Operation – characterized by 1,500-MW NGS operations, with 2 NGS units operating (referred to as the “A1 Scenario” in the ERA reports and represents the lowest amount of future emission under the proposed action); and
- 2-Unit Partial Federal Replacement (PFR) Operation – characterized by 1,400-MW NGS operations, with 2 NGS unit operation and partial replacement (100 MW) by federal partner (referred to as the A1400 Scenario in the ERA reports and provides an estimate of the emissions if the PFR are implemented under a 2-Unit NGS operations).

These three production scenarios were considered for the Gap Regions and San Juan River study areas to estimate future emissions associated with NGS operations, using the air model implemented for that given study area. Only the first two production scenarios were considered for the proposed KMC study area to estimate future emissions associated with NGS operations. The future emissions scenario also considered Other Cumulative Sources (OCS) that may contribute to the environmental load of emissions-related chemicals. These sources include local, regional U.S sources (including Four Corners

Power Plant and San Juan Generating Station, among others), and global sources including emissions from China, described in the following section.

San Juan River ERA Study Area

EPRI conducted a watershed-scale assessment of trace metal deposition and dynamics within the San Juan River watershed attributed to emission of arsenic, mercury, and selenium from three regional power plants (NGS, San Juan Generating Station, and Four Corners Power Plant). Atmospheric modeling of arsenic, mercury, and selenium was conducted using a suite of regional air quality models (WRF, CMAQ-APT, CMAQ, GEOS-Chem) and the output was incorporated into a watershed biogeochemical cycling and aquatic biota bioaccumulation model (WARMF) to estimate concentrations in surface water (arsenic, mercury, and selenium) and invertebrate and fish tissue (mercury). Modeling estimates included contributions of local, regional, and global sources in the San Juan River basin extending downstream and into the San Juan arm of Lake Powell. **Figure 3.0-6** of the EIS depicts the San Juan River watershed within the domain of the EPRI model. The methods used to develop the models are summarized in the EPRI report (EPRI 2016). The San Juan River study area was used to evaluate ecological risk only because the negligible indirect effects could contribute to potential cumulative impacts (Ramboll Environ 2016b).

The models are briefly described below and detailed description and methods used to develop the models are summarized in the EPRI report (EPRI 2016).

- Weather Research and Forecasting (WRF) Model – used along with meteorological monitoring data to simulate the regional atmospheric air quality at 4-km grid resolution.
- Community Multiscale Air Quality-Advanced Plume Treatment (CMAQ-APT) Model – a regional/local scale model used for modeling atmospheric transport and deposition of arsenic, mercury, and selenium and applied over the approximate extent of the San Juan River basin. The model is based on the USEPA CMAQ model and applies an advanced plume treatment (APT) module for higher precision nearest to the source(s) to estimate wet and dry atmospheric deposition.
- CMAQ Model – a regional scale model used for modeling atmospheric transport and deposition of arsenic, mercury, and selenium and applied over the U.S.
- Goddard Earth Observing System with Chemistry (GEOS-Chem) Model – based on the National Aeronautics and Space Administration (NASA) GEOS atmospheric global transport model combined with a Harvard University atmospheric chemistry simulation model, was used to simulate global mercury dynamics.
- Watershed Analysis Risk Management Framework (WARMF) Model – three-dimensional dynamic model used to simulate the watershed transport, transformation and bioaccumulation processes of wet and dry deposited constituents. WARMF was linked to CMAQ-APT wet/dry deposition outputs to calculate concentrations of arsenic, selenium, and mercury in surface water and mercury in the fish tissue. WARMF quantifies the relationship between atmospheric deposition plus direct input from watershed sources of chemicals, and resulting concentrations in surface water.

The coupling of the CMAQ-APT and WARMF models applied in the EPRI analysis has undergone peer-review by experts in academia and government to ensure the accuracy of the models (EPRI 2016).

The objective in the WARMF model was to estimate annual deposition of arsenic, mercury and selenium during the time period of 1990 – 2074 to account for historical contributions to deposition and media concentrations, and "delayed" or latent contribution to fish tissue bioaccumulation after proposed shut down of NGS in 2044. To these ends, atmospheric deposition was simulated for several potential scenarios of emissions from local coal fired power plants as well as regional (U.S) and global sources of mercury beyond of the bounds of the San Juan River basin. Four air dispersion and deposition modeling simulations were conducted:

- Baseline scenario – representing historical emissions and deposition to approximate “current” conditions.
- Regional (U.S) scenario – post-2019 operation of NGS, post-2013 operation for FCPP and post-USEPA Mercury and Air Toxics Standard (MATS) rule for other coal-fired power plants in U.S.
- 2050 Case Low – a lower bound estimate of future Chinese emissions.
- 2050 Case High – a higher bound estimate of future Chinese emissions.

In each of the China cases, FCPP, NGS and SJGS were modeled post-MATS, and current world emissions also were included in the modeling. These China scenarios provide a lower and upper bound mercury scenario to account for uncertainties in future Chinese emissions (EPRI 2016). Each scenario incorporated three alternative NGS emissions scenarios for the period from 2020 to 2044: 2,250 MW (maximum emissions, 3 units operate); 1,500-MW (minimum emissions, 2 units operate); and no emission scenario (all units shut down in 2020).

Gap Regions ERA Study Area

Analysis of the Gap Regions (Ramboll Environ 2016c) was conducted to address potential risks to aquatic and aquatic-oriented wildlife in the Colorado River upstream and downstream of Lake Powell, in areas that were not specifically evaluated in the NGS Near-field or San Juan River ERAs. The Gap Regions study area and chemicals of concern (arsenic, mercury, and selenium only) were defined based on consultation with USFWS and other cooperating agencies specifically to address habitat for several special status fish species. The two Gap Regions, for which one ERA was prepared with separate results provided for the northeast and the southwest gap regions, fall outside of the 20-km NGS Near-field study area and San Juan River study area. They are depicted in **Figure 3.0-6** of the EIS and include:

- **Northeast Gap Region.** This includes the portion of Lake Powell beyond the 20-km NGS Near-field study area and the Colorado River northeast of Lake Powell upstream to the confluence of the Colorado and Green rivers (approximately 274 km upstream of the Glen Canyon Dam).
- **Southwest Gap Region.** This includes the lower Colorado River downstream of the 20-km NGS Near-field study area, from Lees Ferry to the confluence of the Colorado and Little Colorado rivers (approximately 100 km downstream of the Glen Canyon Dam).

The AERMOD model provided deposition data to the extent of the model domain (out to a 50-km radius from NGS) and deposition results for the model domain for mercury, selenium, and arsenic from 20 km to 50 km were considered along with the EPRI model to provide future conditions media concentrations data to characterize emissions and deposition of these chemicals to the watershed/surface water within the Gap Regions.

Kayenta Mine ERA Study Area

The proposed KMC study area was based on consideration of the existing lease property boundaries, the influence of active and proposed future mining activities (deposition area), the presence of human residential areas (to support the human health evaluation), and the presence of special status species and important ecological features (Ramboll Environ 2016d). This area includes key ecological habitats (e.g., seeps and springs), soil, sediment, locations of special status species (i.e., Navajo sedge and Mexican spotted owls), and surface water features that may be affected by potential transport off-site (i.e., via overland flow and/or wind-generated erosion, via groundwater and other release and transport mechanisms). The study area boundaries were determined in consultation with cooperating agencies and are depicted in **Figure 3.0-8** of the EIS.

The deposition area is entirely within the proposed KMC study area and was defined using an approach similar to that used to estimate the NGS Near-field study area, where AERMOD was applied to determine air emission/dispersion and deposition associated with potential proposed KMC sources. Air dispersion and deposition modeling was conducted by McVehil-Monnett Associates, Inc. (2016) to evaluate the deposition of contaminants from mine operations through 2044 assuming continued operations necessary to provide coal for power generation at NGS. Total suspended particulate emissions were identified as the primary source of emission sources at the proposed KMC that may be generated from mining/pit activities, handling of topsoil, overburden (i.e., soil layer overlying coal deposits) and coal, coal processing, pit reclamation, road travel, and heavy equipment tailpipe emissions. In addition to these local sources of future emissions, emissions/deposition from NGS also were considered (NGS at KMC) using the maximum (3-Unit) production scenario.

The proposed KMC ERA study area includes the deposition area that was defined using an approach similar to that used to estimate the Study Area for the Near-field ERA and is based on a selenium deposition contour corresponding to 10 percent of the minimum selenium ecological soil screening level (USEPA 2007), which is equivalent to an aerial deposition rate of 52 micrograms per square meter per year. Air quality analyses were conducted by McVehil-Monnett Associates, Inc. for two reasonably anticipated annual coal production rates: 5.5 million tons per year and 8.1 million tons per year. These scenarios effectively address all potential NGS coal requirements for the future power operation scenarios defined previously. For this and the other scenarios, two worst-case annual operating scenarios were modeled for each alternative:

- 5.5 million tons per year – minimum coal production rate. Maximum emissions were identified for years 2022 (to estimate particulate emissions associated with mining activities near permit boundary) and 2043 (to estimate the highest annual particulate emissions); and
- 8.1 million tons per year – a maximum coal production rate. Maximum emissions were identified for years 2027 (to estimate particulate emissions associated with mining activities near permit boundary) and 2042 (to estimate the highest annual particulate emissions).

The proposed KMC ERA specifically evaluated the 8.1 million tons per year scenario (corresponding to 3-Unit Operation at NGS), and the 5.1 million tons per year scenario (corresponding to 2-Unit Operation at NGS).

1.3 Risk Assessment Datasets

The datasets used for the ecological risk assessments included both measured analytical chemistry data obtained within the defined study areas to represent baseline conditions and chemistry data developed (modeled) using the watershed modeling air dispersion and/or deposition modeling described above (i.e., AERMOD, and/or CMAQ-APT/WARMF per EPRI). The primary abiotic media of concern for the ERAs included soil, surface water, and sediment. In addition, fish tissue also is of interest. The datasets evaluated for each ERA included COPECs for ecological evaluations that were defined for the Project in development of the study plans. The full listing of COPECs include hazardous air pollutants such as metals/inorganic chemicals, organic chemicals including benzene and other volatile organics, and semi-volatile organics such as polycyclic aromatic hydrocarbons (PAHs) and dioxins/furans for the NGS Near-field ERA and the KMC ERA. Arsenic, mercury and selenium were the COPECs evaluated for the San Juan River and Gap Regions ERA. Datasets used to develop risk estimates were refined to relevant datasets for each specific evaluation conducted to address site-specific considerations as defined in the supporting technical documents (Ramboll Environ 2016a,b,c,d). A summary listing of all COPECs as relevant to each ERA is provided in **Table 3RA-2**.

The datasets used for each of the Ramboll Environ risk assessments to describe baseline conditions are briefly described below and include:

- NGS Near-field ERA – NGS Near-field Investigation Report (Ramboll Environ 2016e) describes the methods and results for abiotic sampling data collected in summer 2014 from soil, surface water and sediment within the NGS study area.
- San Juan River ERA – baseline conditions data were based on sources available in the literature for fish tissue, surface water and sediment. Key sources included:
  - Fish Tissue – USFWS (Simpson and Lusk 1999); Utah Department of Environmental Quality-Division of Water Quality (UDEQ-UDWQ 2008); and USGS (Water Quality Portal Database).
  - Surface Water and Sediment – USFWS (Simpson and Lusk 1999); USGS (Water Quality Portal Database; Hart et al. (2012); National Uranium Resource Evaluation (NURE) Database, and National Geochemical Survey Database
- Gap Regions ERA – baseline conditions data were based on existing data developed during the Near-field ERA where applicable, and sources available in the literature for fish tissue, surface water and sediment. Key sources included:
  - Fish Tissue – USEPA (Olsen et al. 2009a; USEPA 2009a,b); USFWS (Lusk 2010; Lusk et al. 2005; Simpson and Lusk 1999;USFWS 2014; National Contaminant Biomonitoring Program [Jacknow et al. 1986]); Utah Division of Wildlife (UDWQ 2008); USGS (Eagles-Smith et al. 2014; Hinck et al. 2006, 2003; Kepner 1988 (unpublished data); Walters et al. 2015; Water Quality Portal Database).
  - Surface Water – Water Quality Portal Database and NGS Near-field data used to estimate water concentration upstream and downstream of the 20-km study area.
  - Sediment – National Geochemical Survey Database and NGS Near-field data used to estimate water concentration upstream and downstream of the 20-km study area.
- Proposed KMC ERA – Proposed KMC Sampling Investigation Report (Ramboll Environ 2016g) describes the methods and results for abiotic sampling data collected in summer 2014 from soil, surface water and sediment within and adjacent to the proposed KMC study area.

As a component of the Near-Field ERA and Proposed KMC ERA, baseline soil conditions determined through site-specific field sampling efforts (Ramboll Environ 2016e,f) were compared to natural/anthropogenic background levels for the region reported in the web-based United States Geologic Survey (USGS) web-based USGS Soil Survey Geographic Database to provide context to the measured baseline soil concentrations. For future scenarios the following key data sources were used in the ERAs:

- NGS Near-field ERA – Air dispersion and deposition modeling using AERMOD was performed to quantify future impacts of NGS operations from 2020 to 2044 (Ramboll Environ 2016a). Impacts of mercury emissions from sources other than NGS including local, regional and non-U.S. sources (OCS) were characterized using mercury deposition data from the EPRI San Juan River Basin study (EPRI 2016).
- San Juan River ERA – fish tissue and invertebrate tissue (mercury only), and surface water (arsenic, mercury and selenium) data were developed from deposition data from the GEOS-Chem and CMAQ-APT modeling results per the EPRI San Juan River Basin study (EPRI 2016).
- Gap Regions ERA – Near-field AERMOD air dispersion model for operations from 2020 through 2044 for arsenic, mercury, selenium from 20 km extent out to 50 km (the full computational domain of AERMOD). Beyond the 50 km AERMOD extent, the deposition data from the GEOS-Chem and CMAQ-APT modeling results per the EPRI San Juan River Basin study (EPRI 2016) were used.

- Proposed KMC ERA – air dispersion modeling using AERMOD (MMA 2015) was performed to quantify future impacts of mining activities at proposed KMC from 2020 to 2044. In developing exposure scenarios for the ERA (and HHRA), the influence of NGS emissions at the proposed KMC was conducted to consider the potential additivity of ecological exposure that could occur if NGS emission were deposited at the KMC. To that end, NGS AERMOD results at 50 km from NGS, where the NGS and KMC AERMOD domains overlap, also were considered (Ramboll Environ 2016d). Impacts of mercury emissions from sources other than NGS and proposed KMC, including non-US sources (OCS), were characterized using modeled mercury deposition rates from the EPRI San Juan River Basin study (EPRI 2016).

Methodologies for estimating chemical concentrations in environmental medium as recommended in the USEPA Human Health Risk Assessment Protocol (HHRAP, USEPA 2005) were used to translate air modeling results into media concentrations. Concentrations in fish tissue were modeled into fish based on COPEC concentrations in surface water. For the San Juan River ERA, invertebrate and fish tissue concentrations were estimated directly for mercury by the CMAQ-APT/WARMF model as reported in the EPRI San Juan River Basin study (EPRI 2016), while arsenic and selenium tissue concentrations were estimated via a food web model from surface water concentrations into fish.

For the risk assessments, these baseline and future scenario data were used directly as environmental concentrations for comparison to ecological screening values and/or indirectly as food web model inputs to predicted chemical concentrations in food items that may include: plants, invertebrates, small mammals and fish, as applicable. A total daily dose was calculated for each species in order to estimate dietary exposure to wildlife which was then compared to a toxicity reference value in order to determine potential risk.

1.4 Ecological Risk Assessment Process Overview

This section provides a brief ERA process overview for each ERA component: Problem Formulation, Exposure Assessment, Toxicity Assessment, Risk Characterization and Uncertainty Analysis. The process overview discusses risk assessment as it applies to each ERA conducted for the Project. Key exposure and toxicity assumptions particular to a given ERA are discussed in the summary of ERA results presented subsequently.

The Problem Formulation synthesizes what is known or predicted for a given study area under evaluation to develop a CSM that will guide the ERA process (USEPA 1997). The problem formulation identifies the environmental setting and ecological habitat characteristics, representative receptors of interest (drawn from the potential ecological receptors with expected or observed presence), COPECs, media of interest, exposure pathways, and develops assessment endpoints and measures of effect to evaluate ecological risk. Some receptors may be evaluated as individual populations or individual organisms of a species, while others are evaluated as ecological communities (i.e., an aggregate of organism populations).

Conceptual site models that illustrate potentially complete exposure pathways for each of the study areas is discussed in detail in each of the ERAs conducted for the Project (Ramboll Environ 2016a,b,c,d), and COPECs identified for each ERA were summarized in **Table 3RA-2** and will not be repeated here. **Table 3RA-3** presents a summary of the receptors, exposure pathways and also presents the outcome of the problem formulation, summarizing the assessment endpoints and measurement endpoints for each of the representative receptors and relevant exposure pathways selected for evaluation in the ERAs.

1.4.1 Key Exposure and Toxicity Assumptions Applied for the Ecological Risk Assessments

The exposure assessment presents the assumptions and parameters used to develop estimates of exposure. Per USEPA guidance (USEPA 1997), the ERA is an evaluation based on conservative assumptions and is intended to eliminate COPECs with no potential to cause risk. The refined evaluation allows for refinement of COPECs identified in the initial tier (screen) as having a potential to cause risk, and allows for the identification and characterization of current and future risk using site-specific/more realistic assumptions regarding exposure. For these ERAs, all COPECs were retained throughout the screening and refinement steps. The screening results (using maximum COPEC concentrations) and refined and average results (using the 95% UCL and average COPEC concentrations) are presented together rather than as separate sections of the ERA so that the reviewer can see the range of HQs using average, refined and maximum COPEC concentrations.

An ecological community is a group of actually or potentially interacting species living in the same area. In the context of the ERAs, community receptors are assessed as a group such as the terrestrial plant community, the terrestrial invertebrate community, and the benthic invertebrate community. Assessing contaminant exposure in ecological communities is based upon the integration of all exposures (via multiple uptake/exposure pathways) into a media-specific (soil, sediment or water) ecological screening value irrespective of any food-web modeling. For example, plant communities experience direct uptake via roots and/or foliage and plant benchmarks are developed based on the administered dose (to soil and/or foliage) without consideration of uptake, uptake rates, and other food-web based exposure assumptions.

Wildlife exposure uses food-web modeling to estimate exposure dose or total daily dose (TDD) based on exposure via the diet. The dose is modeled using EPCs and exposure parameters for a given representative receptor. The ingested dose equation to model exposure for a wildlife receptor, reproduced from the Near-field ERA (Ramboll Environ 2016a), is presented below for reference.

$$TDD = \frac{([IRfood\ x\ Cfood] + [IRsoilsed\ xCsoilsed] + [IRwater\ x\ Cwater])x\ AUF\ x\ AF}{BW}$$

Where:

TDD	=	Total daily dose (mg COPEC/kg wet weight per day [ww/day)
IRFOOD	=	Ingestion rate of food (kg/day)
CFOOD	=	Concentration of the COPEC in food (mg/kg)
IRSOIL/SED	=	Ingestion rate of sediment or soil (kg/day)
CSOIL/SED	=	Concentration of COPEC in soil or sediment (mg/kg)
IRWATER	=	Ingestion rate of water (L/day)
CWATER	=	Concentration of COPEC in water (milligrams per liter [mg/L])
AUF	=	Area use factor (unitless)
AF	=	Assimilation factor (unitless)
BW	=	Body weight (kg ww)

and:

$$C_{FOOD} = \sum((C_{FOOD1} + P_{FOOD1}) + (C_{FOOD2} + P_{FOOD2}) + (C_{FOOD\ i} + P_{FOOD\ i}))$$

C_{FOOD}	=	Concentration of COPEC in food (mg/kg)
C_{FOOD1}	=	C_{MEDIUM} x BAF_{FOOD1} (mg/kg)
P_{FOOD1}	=	Proportion of diet composed of food item 1 (unitless)
C_{FOOD2}	=	C_{MEDIUM} x BAF_{FOOD2} (mg/kg)
P_{FOOD2}	=	Proportion of diet composed of food item 2 (unitless)
$C_{FOOD\ i}$	=	C_{MEDIUM} x $BAF_{FOOD\ i}$ (mg/kg)
$P_{FOOD\ i}$	=	Proportion of diet composed of the i^{th} food item (unitless)
BAF_{FOOD1}	=	Bioaccumulation factor for first food item (unitless)
BAF_{FOOD2}	=	Bioaccumulation factor for second food item (unitless)
$BAF_{FOOD\ i}$	=	Bioaccumulation factor for the i^{th} food item (unitless)

The exposure assessment involves defining each of the input parameters needed to assess exposure including development of exposure point concentrations or concentration of COPEC in media, life history parameters and chemical-specific uptake factors, all of which are used in development of quantitative estimates of exposure. Key assumptions regarding these input parameters common to all evaluations are presented below. The reader is referred to the ERA technical documents for specific parameters and sources:

- Life History parameters – include wildlife characteristics that allow for development of exposure estimates. Key parameters include food and water ingestion rate, dietary composition, animal body weight and foraging range. For the four ERAs, central tendency estimates (e.g., average values) were used wherever possible for all life history parameters in order to develop exposure estimates for both the maximum exposure and refined scenarios. For simplicity, the same set of life history parameters were used in the ERAs for maximum and refined exposure scenarios. Key sources for life history parameters include USEPA (USEPA 1993) and Oak Ridge National Laboratory (Sample et al. 1996).
- Uptake Factors – Bioaccumulation factors (BAFs) estimate prey tissue concentrations in the absence of empirical tissue concentration data; this estimate is based on the product of the BAF and media concentration. Literature BAFs are available for soil to terrestrial invertebrates, soil/sediment to plants, soil to small mammals; and sediment to benthic invertebrates and sediment and/or surface water to fish. Key sources for uptake factors include USEPA EcoSSL guidance (USEPA 2007) and USEPA Region 6 Combustion Guidance (USEPA 1999).
- Exposure Point Concentrations (EPCs) – refer to media (i.e., soil, water, sediment and food) concentrations to which animals and plants may be exposed. The ERAs included EPCs for each of the various scenarios evaluated (e.g., baseline, B2, etc.) based on the following:
- Maximum Exposure Scenario – a conservative screening estimate of the EPC is used (maximum concentration) and is based on assumption that all receptors are exposed to the maximum concentration detected for each medium of concern relevant to that receptor.
- Refined Exposure Scenario – 95 percent upper confidence limit (95% UCL) is used as the EPC if it can be calculated. If a 95% UCL cannot be calculated, the maximum value is used as the refined concentration. The arithmetic mean also is considered within the context of the refined exposure scenario, especially in instances where a 95% UCL cannot be calculated.

The 95% UCL of the arithmetic mean reported in the ERAs was calculated using ProUCL version 5.0.00 (USEPA 2013) wherever data density (i.e., n≥6) and COPEC detection were sufficient to compute the 95% UCL of the mean; otherwise, the maximum detected concentration (MDC) was applied.

For the ERAs conducted for the Project, there were multiple scenarios evaluated for each receptor under maximum, refined and average exposure scenarios. The basic scenarios evaluated include:

- Baseline
- Future NGS Operations and KMC
  - 3-Unit (B2)
  - 2-Unit (A1)
  - 2-Unit Partial Federal Replacement (A1400)
- Other Cumulative Sources (OCS)
- Total Cumulative = Baseline + Future NGS and KMC Operations + Other Cumulative Sources
- No Action Alternative = Baseline + Other Cumulative Sources

The toxicity assessment evaluates available toxicity and other effects information to correlate the exposure to adverse effects. Toxicity reference values (TRVs) that correlate a specified effect to a given chemical concentration are used to characterize potential ecological effects. The effects data used to evaluate ecological risks resulting from chemical exposure were obtained from literature-derived single-chemical toxicity data. Toxicity data used to develop risk estimates were presented in each of the ERAs developed for the Project (Ramboll Environ 2016a,b,c,d).

Community-level receptors (i.e., terrestrial invertebrates, terrestrial plants, benthic invertebrates, and aquatic biota including fish) are assumed to be exposed to constituents on a continuous whole body basis. Assessing constituent exposure to ecological communities is, therefore, based upon the integration of all exposures into a single criterion for the medium of exposure (i.e., the ecological screening value). Toxicity data are literature-derived medium-specific values (e.g., soil, surface water, sediment screening benchmarks). These values are based on no observed effect concentration (NOECs) and/or lowest observed effect concentrations (LOECs) and are considered protective of the community for which they were derived.

The following were the key sources of ecological screening values and toxicity data used in the ERA reports and are from generally recognized sources. Other sources also were considered in the absence of information in these primary sources.

- Soil Screening Values
  - USEPA Eco-SSL plant-based and soil invertebrate-based values (http://www.epa.gov/ecotox/ecossl/).
  - USEPA Region 6 Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (USEPA 1999).
  - ORNL terrestrial plant and invertebrate (earthworm) screening values (Efroymson et al. 1997a,b). Values for soil microorganisms and microbial processes (Efroymson et al. 1997b) were used in cases when earthworm-based values are not available.
- Sediment Screening Values
  - USEPA Region 6 Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (USEPA 1999).

  - National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (Buchman 2008). Threshold effects concentrations (TECs) from consensus-based sediment quality guidelines (MacDonald et al. 2000) were preferentially selected where available.
  - USEPA Region 3 (USEPA 2006) freshwater screening values.
- Surface Water Screening Values
  - USEPA National Ambient Water Quality Criteria (USEPA 2015).
  - Standards for Interstate and Intrastate Surface Waters, Title 20 Chapter 6 Part 4 (New Mexico Water Quality Control Commission 2012).
  - Navajo Nation Surface Water Quality Standards (Navajo Nation Environmental Protection Agency 2004).
  - Arizona Department of Environmental Quality water quality standards for surface (Arizona DEQ 2009).
  - USEPA Draft Aquatic Life Ambient Water Quality Criterion for Selenium (Freshwater) (USEPA 2015).
  - Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities: Appendix E, Toxicity Reference Values (USEPA 1999).
  - Utah Department of Environmental Quality water quality management: Standards (Utah DEQ 2014).
  - Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota – 1996 Revision (Suter and Tsao 1996).

Aquatic community receptors were evaluated by comparison of medium-specific concentrations to applicable ecological screening values. For evaluation of aquatic organisms, use of the dissolved (filtered) water concentration is generally of most relevance for metals (including arsenic and mercury/methylmercury) and organic chemicals, as dissolved concentrations represent the bioavailable fraction of COPECs. The exceptions are aluminum and selenium that are typically evaluated using total (unfiltered) concentrations.

- Critical Body Residue Values
  - Jarvinen and Ankley database (1999), primary source of CBRs used in evaluation of fish tissue residues for COPECS other than mercury.
  - U.S. Army Corps of Engineers (USACE) Environmental Residue Effects Database (ERED), another primary source of CBRs used in the evaluation of fish tissue residues for COPECs other than mercury.
  - Beckvar et al. (2005), source for a value of 0.2 mg/kg wet weight for mercury used for special status fish species and early life stage fish. A CBR of 0.77 mg/kg wet weight was used for general (representative/non-special status) fish in the food web model.
  - USEPA (2015) Draft Aquatic Life Ambient Water Quality Criterion for Selenium.
- Toxicity Reference Values
  - USEPA. 2007c. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Attachment 4-5 Eco-SSL Standard Operating Procedure (SOP) #6: Derivation of Wildlife Toxicity Reference Value. OSWER Directive 9285.7-55. Revised June.
  - USEPA. 2002. USEPA Region 9 Biological Technical Assistance Group (BTAG) Recommended Toxicity Reference Values for Mammals. Revision Date 11/21/02.

- USEPA. 2009b. USEPA Region 9 Biological Technical Assistance Group (BTAG) Recommended Toxicity Reference Values for Birds. Revision Date 02/24/09.
- Sample et al. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. June 1996. ES/ER/TM-86/R3.
- LANL. 2012. Los Alamos National Laboratory (LANL) Ecorisk Database (Release 3.1). Available at: http://www.lanl.gov/community-environment/environmentalstewardship/protection/eco-risk-assessment.php

Two types of toxicity reference values (TRVs) were considered to develop risk estimates for wildlife.

- NOAEL-base TRVs – toxicity data applied for the ERAs are no observed adverse effect level (NOAEL) or equivalent no observed effect concentrations (NOECs). Use of no effect level values is appropriate when assessing potential risk to federally listed species. These values represent the concentration at or below which the potential for adverse effects are not expected.
- LOAEL-based TRVs – a second set of toxicity data applied for the ERAs are lowest observed adverse effect level (LOAELs) or equivalent lowest observed effect concentrations (LOECs). Use of lowest effect level values is appropriate when assessing potential risk to non-listed species and is generally considered protective of organism populations. These values represent the concentration at or above which there is a potential for adverse effects. The LOAEL/LOEC values are considered only in the refined exposure scenario.

1.4.2 Key Concepts for Risk Estimation and Description

Risk estimation uses quantitative methods to evaluate the potential for risk. Risk estimates are derived for each assessment endpoint using the defined measures of exposure (medium-specific maximum and refined concentrations) and effect (chemical-specific TRVs) of each defined exposure scenario. The risk description considers the quantitative risk estimates and, along with other lines of evidence (e.g., habitat and vegetation quality, consideration of background conditions, receptor diet) and potentially affected receptor groups, serves to identify chemicals for additional consideration.

For ecological community-level receptors, the potential risk is estimated by direct comparison of measured concentrations of COPECs in soil, sediment, surface water or fish tissue to their respective screening level or benchmark TRVs. These comparisons apply to the soil community (terrestrial plants and terrestrial invertebrates) exposed to soil the aquatic community (fish, and other aquatic biota including aquatic invertebrates, plants and amphibians) exposed to surface water, and benthic invertebrates exposed to sediment using the following relationship:

$$HQ = \frac{Maximum\ Detected\ Concentration\ or\ 95\%\ UCL}{Ecological\ Screening\ Value\ (ESV)}$$

The hazard quotient is a unitless value that relates the measured (or modeled using uptake factors) concentration in site media (e.g., soil) to a known literature-based toxicity level expressed in the same units of measure (e.g., milligrams per kilogram). Chemical concentrations in excess of literature-based toxicity levels indicate a potential for adverse effects to a given community. In general, media-specific concentrations less than or equal to the applicable ecological screening value (typically based on a no effect level) are unlikely to result in impairment of health for ecological receptors and can be effectively eliminated from further consideration. The risk estimates for community level receptors (organism populations), based on comparison of applicable ecological screening values (protective of organism health) to medium-specific concentrations, may be interpreted as follows:

- HQ_{max} less than or equal to 1
  - Ecological risk is highly unlikely
  - No further concerns
- $HQ_{refined}$ less than 1 but HQ_{max} greater than 1
  - Ecological risk to individual organisms possible
  - Ecological risk to organism populations is unlikely or negligible
  - Evaluate other lines of evidence (e.g., background conditions) to draw conclusions
- $HQ_{refined}$ greater than 1
  - Ecological risk to community/population may be possible
  - Evaluate other lines of evidence (e.g., background conditions) to draw conclusions

For birds and mammals, the risk estimate is based on a hazard quotient defined as the ingested dietary dose (i.e., the intake of chemicals in soil or sediment, food, and water) divided by the chemical-specific toxicity reference value expressed in the same units of measure (i.e., milligrams food/water per kilogram body weight per day):

$$HQ = \frac{Dietary\ Dose}{Toxicity\ Reference\ Value}$$

Food web biotransfer from contaminated media to biota is based on assumptions that generally result in conservative estimates of exposure dose. For bird and mammal evaluations, the hazard quotient may be interpreted as follows:

- No observed adverse effect level hazard quotient_{max} is less than or equal to 1
  - Ecological risk is highly unlikely
  - No further concerns.
- No observed adverse effect level hazard quotient_{max} greater than 1 but no observed adverse effect level hazard $\text{quotient}_{refined}$ less than or equal to 1
  - Ecological risk to individual organisms possible.
  - Ecological risk to organism populations is unlikely or negligible.
  - Evaluate other lines of evidence (e.g., background concentrations) to draw risk conclusions.
- No observed adverse effect level $HQ_{refined}$ greater than 1 but lowest observed adverse effect level $HQ_{refined}$ less than 1
  - Ecological risk to individual organisms possible
  - Ecological risk to population is low or negligible
  - Evaluate other lines of evidence (e.g., background conditions) to draw conclusions
- Lowest observed adverse effect level hazard $\text{quotient}_{refined}$ greater than or equal to 1
  - Ecological risk to population may be present.
  - Proceed to risk management and/or consider additional lines of evidence and/or studies to further refine risk estimate.

The HQ is not a predictor of risk but rather is tool used to evaluate potential risk and to identify chemicals that can be eliminated from further study (i.e., no potential risk) and for which additional evaluation may be required (Allard et al. 2009; USEPA 1997). It is important to recognize that the magnitude of the HQ is not comparable across (or within) representative receptors (i.e., an HQ of 10 for one receptor is not necessarily "worse" than a HQ of 5 for another), as the underlying dose-response relationship may not be linear or comparable between representative species (Allard et al. 2009).

Due to the inherent uncertainties in uptake, toxicity, and exposure terms included in the calculation, the level of mathematical precision of an HQ is only considered reliable to one significant digit. Providing additional significant digits (e.g., to the nearest tenth, HQ=5.6) compounds this uncertainty and overstates the level of confidence in the HQ.

1.4.3 Ecological Risk Assessment Results

The ERA quantified chemical risk for representative ecological receptors selected based on ecological conceptual site models (CSMs), which graphically and narratively describe the relationship between potential source, release mechanisms (e.g., aerial deposition, wind-generated dusts) and environmental exposure to potential receptors (animals and plants). Risk characterization is the estimation and description of risk based on the exposure and toxicity assessment and also considers the uncertainties associated with the estimation and description of risk (USEPA 1999, 1998, 1997). Two primary estimates of risk were developed for the ERAs:

- Screening or Maximum evaluation. An initial tier of evaluation that uses the maximum estimate of exposure and toxicity to return a conservative estimate of risk (HQ_{max}).
- Refined evaluation. A subsequent tier of evaluation where the risk estimate ($HQ_{refined}$) is developed using refined exposure assumptions and toxicity data. This step was applied to each COPEC regardless of whether ecological risk could be excluded using the maximum concentration.

The outcome of the refined evaluation represents a scientific management decision point (USEPA 1997) in which the conclusion of acceptable (negligible risk) or unacceptable ecological risk is used to guide risk management decisions or define additional data needs to further characterize risk. . For special status species, the protection of individual organisms is of most importance and so results based on maximum and refined EPCs and no effect toxicity data are of most relevance. For non-listed species the goal is protection of the organism population and so focus on refined results considering central tendency media concentrations (95% UCL and average) and no effect toxicity data and lowest effect toxicity data, where applicable, is appropriate. For all receptors evaluated in the ERAs, the maximum and refined concentrations were initially compared to no effect toxicity data to return conservative estimates of risk. As warranted, the lowest effect toxicity data were used to provide a more realistic estimate of risk for organism populations.

Summary of Risk Assessment Results

The results summarized below are representative of the affected environment (baseline conditions), and environmental consequence (future conditions) that includes NGS or KMC and other cumulative sources. **Table 3RA-7** through **Table 3RA-9** provide a summary of the risk results for all receptors evaluated for the ERAs.

Near-field ERA

The Near-field ERA evaluated the potential for risk to ecological receptors from exposure to chemicals associated with baseline conditions, future NGS sources, and other cumulative sources (OCS) from regional/global emissions and deposition. The Near-field study area is known to support various wildlife species and plant and animal communities, and representative receptors were selected from among plant and animal groups known or expected to occur regionally, including special status (State and/or

Federally Species listed as threatened or endangered). **Table 3RA-3** presents a concise summary of the receptors, assessment and measurement endpoints and media of concern evaluated for the Near-Field ERA evaluated for the Near-field ERA.

Based on the results of the NGS Near-field ERA, population, community, and ecosystem level risk for aquatic and terrestrial species are unlikely as a result of NGS emissions. The baseline and future risks to aquatic and terrestrial receptors within the NGS Near-Field Study Area provided in **Table 3RA-4** (terrestrial) and **Table 3RA-5** (aquatic) and can be summarized as follows. The reader is referred to the NGS Near-field ERA (Ramboll Environ 2016a) for full detail regarding results.

<u>Baseline Risk Summary</u>

- Concentrations of key COPECs are consistent with or below background concentrations for the area within 150 km of the NGS and within the State of Arizona.
- Baseline conditions do not pose unacceptable risks to special status species, including the western yellow-billed cuckoo, the Southwestern willow flycatcher, and the special status plant and fish species, if present (all maximum HQs<1).
- Current conditions do not pose unacceptable risks to the terrestrial plant community, soil invertebrate community, or the aquatic community and benthic invertebrate community (all refined HQs<1).
- Current conditions do not pose unacceptable risks to non-special status terrestrial or aquatic-oriented mammal and bird populations (refined HQs<1).

<u>3-Unit and OCS Risk Summary</u>

- All 3-Unit and OCS HQs were well below 1 for the terrestrial plant community, soil invertebrate community, or the aquatic community, benthic invertebrate community using maximum concentrations of COPECs
- 3-Unit and OCS HQs using maximum concentrations and NOAEL TRVs were below 1 for each COPEC-receptor combination.
- 3-Unit and OCS future contributions from NGS do not pose a risk to fish, bird or mammal populations, including special status species.

<u>Total Cumulative Risk Summary (Baseline+3-Unit+OCS)</u>

- All total cumulative risk HQs using refined concentrations of COPECs were below 1 for the terrestrial plant community, soil invertebrate community, aquatic community or benthic invertebrate community.
- All maximum total cumulative fish tissue HQs were below 1 suggesting that risk to both representative and special status fish, if present, is highly unlikely.
- All total cumulative risk HQs using refined concentrations of COPECs were below one for all non-special status wildlife COPEC-receptor combinations.

These results suggest that contributions from baseline, other regional/global sources and future NGS operations do not pose a risk to representative or special status wildlife within the NGS Near-Field Study Area.

Gap Regions ERA

The Gap Regions ERA evaluated the potential for risk to ecological receptors from exposure to chemicals associated with NGS and regional/global emissions and deposition in two subareas:

Northeast Gap area and Southwest Gap area. Baseline, future NGS operations and OCS scenarios were evaluated for a number of ecological receptors based on exposure to surface water and sediment and exposure via the food chain. The Gap Regions study area is known to support various aquatic oriented wildlife species and aquatic plant and animal communities, and representative receptors were selected from among plant and animal groups known or expected to occur regionally including special status (state and/or federally listed as threatened or endangered). This area was included for evaluation based on request from USFWS to evaluate those aquatic areas that were not specifically addressed as part of the Near-field ERA or the San Juan River ERA. **Table 3RA-3** presents a concise summary of the receptors, assessment and measurement endpoints and media of concern evaluated for the Gap Regions ERA. Only arsenic, mercury, methylmercury and selenium were evaluated in the Gap Region ERA.

Northeast Gap

Based on the results of the Gap Regions ERA for the Northeast Gap, population, community, and ecosystem level impacts for aquatic and aquatic-oriented species are unlikely as a result of NGS emissions. The baseline and future risks to aquatic/aquatic-oriented receptors within the Northeast Gap Region Study Area are provided in detail in **Table 3RA-6** and can be summarized as follows:

Baseline Risk Summary

- Aquatic Community and Benthic Community - refined HQs based on total and dissolved concentrations of COPEC in surface water and sediment were less than or equal to 1. Risk not expected based on direct contact of aquatic community to surface water or direct contact of benthic community to sediment.
- Early Life Stage (ELS) Fish - CBR HQs using maximum concentrations exceeded 1 for mercury (HQ=4), however ELS CBR HQs were below 1 using refined concentrations. Risk is not expected.
- Adult Non-Special Status Fish - all CBR HQs were below 1 using maximum baseline tissue conditions. Risk is not expected.
- Special Status Species Fish - CBR HQs based on maximum and refined fish tissue concentrations measured in surrogate fish species were below 1 for each species evaluated. Risk is not expected.
- Aquatic-Oriented Non-Special Status Representative Wildlife - HQs exceeded 1 for the muskrat (arsenic HQ=2, mercury HQ=2, and selenium HQ=2), raccoon (selenium, HQ=2), and little brown bat (selenium, HQ=2) using maximum concentrations and NOAEL TRVs. However, HQs for all COPEC-receptor pairs in the refined evaluation were below 1. Risk is not expected.
- Aquatic-Oriented Special Status Species Wildlife - HQs for the special status bird species (willow flycatcher and yellow-billed cuckoo) were below 1 using maximum and refined COPEC concentrations. Risk is not expected.

3-Unit and OCS Risk Summary

- All 3-Unit HQs were well below 1 for aquatic community, benthic community, fish, and aquatic-oriented bird and mammal populations, including special status species, using maximum concentrations of COPECs indicating that 3-Unit emissions do not contribute appreciably to risk estimates. Risk is not expected.
- All OCS HQs were below 1 for aquatic community, benthic community, non-special status species fish, and aquatic-oriented bird and mammal populations including special status species using maximum concentrations of COPECs indicating that OCS emissions do not contribute to risk for these receptors. Risk is not expected.

- Special Status Species Fish - maximum OCS CBR HQs were equal to 1 for mercury for each of the special status fish species evaluated, indicating an appreciable contribution from OCS. However, all refined CBR HQs were less than 1. Risk is not expected.

Total Cumulative Risk Summary (Baseline+3-Unit+OCS)

- Aquatic Community and Benthic Community - with the exception of maximum concentrations of selenium in surface water, all total cumulative risk HQs (Baseline + 3-Unit + OCS) using maximum concentrations of COPECs in water and sediment were below one for all COPEC-receptor combinations. All HQs using refined concentrations of COPECs in surface water and sediment were below 1. Risk is not expected.
- Early Life Stage (ELS) Fish - CBR HQs using maximum modeled COPEC concentrations exceeded 1 for mercury (HQ=4), but all refined CBR HQs were less than 1. Risk is not expected.
- Adult Non-Special Status Fish – CBR HQ using maximum modeled and measured COPEC concentrations were less than or equal to 1, and all CBR HQs (using modeled and measured data) were less than 1 in the baseline evaluation. Risk is not expected.
- Special Status Species Fish - CBR HQs based on maximum concentrations exceeded 1 for mercury (HQ=2) for all five special status fish (using surrogate species). Exceedance was driven by contribution of OCS to baseline risk. However, refined fish tissue concentrations measured in surrogate fish species were equal to 1 for each species evaluated. Risk is not expected.
- Aquatic-Oriented Special Status Species Wildlife - maximum total cumulative risk HQs for the southwestern willow flycatcher and yellow-billed cuckoo were below 1 indicating that maximum emissions from future operations will not adversely affect these listed birds. Risk is not expected.
- Aquatic-Oriented Non-Special Status Representative Wildlife - while total cumulative HQs using maximum COPEC concentrations and NOAEL TRVs exceeded 1 for the bald eagle (methylmercury, HQ=2), little brown bat (selenium, HQ=2), raccoon (selenium, HQ=2), and muskrat (arsenic, mercury and selenium, HQ=2), all total cumulative risk HQs using refined concentrations of COPECs were below 1 for all COPEC-receptor pairs. Risk is not expected.

Southwest Gap

Based on the results of the Gap Regions ERA for the Southwest Gap, population, community, and ecosystem level risk to benthic organisms, early life stage fish and special status species birds are unlikely. However, there is a potential for risk for the aquatic community from selenium (driven by baseline conditions), non-special status fish from mercury and selenium for some individual fish species populations, special status fish (humpback chub, roundtail chub, bonytail chub and razorback sucker) from mercury, and herbivorous, omnivorous and insectivorous mammal populations from selenium. The baseline and future risks to aquatic/aquatic-oriented receptors within the Southwest Gap Region Study Area are provided in detail in **Table 3RA-7** and can be summarized as follows:

Baseline Risk Summary

- Aquatic Community and Benthic Community – maximum and refined HQs were below 1 based on COPEC concentrations in surface water (dissolved) and sediment. The maximum and refined HQ exceeded 1 for selenium (HQ=6) only based on total surface water concentration, however all refined HQs for remaining COPECs were less than 1. The selenium exceedance for the refined HQ is based on the maximum concentration (a conservative value due to a small dataset) and the average concentration used in the refined evaluation also exceeds 1 (HQ=2). With the exception of selenium in surface water, risk is not expected for aquatic community direct contact surface water or direct contact of benthic community to sediment.

- Early Life Stage (ELS) Fish – CBR HQs using maximum and refined modeled COPEC concentrations were below 1 for each COPEC. Risk is not expected.
- Adult Non-Special Status Fish – CBR HQs using maximum and refined modeled COPEC concentrations were below 1 for all COPECs. Maximum and refined measured mercury and selenium CBR HQs exceeded 1 for individual fish species, with refined HQs=2 for all fish showing exceedances. However, refined CBR HQ were less than or equal to 1 based on the average of all fish species evaluated suggesting risk to the fish community as a whole may be acceptable, although the potential for risks from mercury and selenium cannot be ruled out for certain species of fish in the Southwest Gap Region.
- Special Status Species Fish – CBR mercury HQs were below 1 for each fish species evaluated with the exception of razorback sucker (HQ=5 using maximum tissue concentration, and HQ=3 using refined tissue concentration for the surrogate, flannelmouth sucker). When bluehead sucker is used as a surrogate for the razorback sucker, the HQs were less than 1. Potential for risks from mercury cannot be ruled out for the razorback sucker.
- Aquatic-Oriented Non-Special Status Representative Wildlife – HQs exceeded 1 for all avian receptors evaluated using maximum and refined concentrations and NOAEL TRVs for methylmercury (refined HQ=3 for all). However, refined HQs for birds using LOAEL TRVs were less than 1 indicating that risk is not expected for bird populations. For mammals, HQs exceeded 1 using maximum and refined concentrations and NOAEL TRVs for methylmercury for muskrat and raccoon (refined HQ=2) and selenium for all mammalian receptors (range of HQ= 2-3). The methylmercury refined HQs for mammals were less than 1 based on LOAEL TRVs, however all LOAEL-based HQs for selenium (HQ=2 for each mammalian receptor) exceeded 1, indicating a potential for risk for herbivorous, omnivorous and insectivorous mammal populations.
- Aquatic-Oriented Special Status Species Wildlife – HQs for the special status southwestern willow flycatcher and western yellow-billed cuckoo were below 1 using maximum and refined concentrations and NOAEL TRVs. Risk is not expected.

3-Unit and OCS Risk Summary

- All 3-Unit HQs were well below 1 for aquatic community, benthic community, fish, and aquatic-oriented bird and mammal populations, including special status species, using maximum concentrations of COPECs indicating that 3-Unit emissions do not contribute appreciably to risk estimates. Risk is not expected.
- All OCS HQs were below 1 for aquatic community, benthic community, non-special status species fish, and aquatic-oriented mammal populations including special status species using maximum concentrations of COPECs indicating that OCS emissions do not contribute to risk for these receptors. Risk is not expected. However, some OCS HQs exceeded 1 for special status species fish and non-special status species birds, discussed below.
- Special Status Species Fish - maximum and refined OCS CBR HQs were greater than 1 for mercury (HQ=4 maximum, and HQ=2 refined) for each of the special status fish species evaluated, indicating an appreciable contribution to risk from OCS. Maximum and refined OCS CBR HQs were less than 1 for all other COPECs. The potential for risk from OCS alone cannot be ruled out.
- Aquatic-Oriented Non-Special Status Representative Wildlife - OCS HQs using maximum and refined concentrations and NOAEL TRVs were below 1 for each COPEC-receptor pair with the exception of the OCS contribution of methylmercury for the bald eagle (refined HQ=2). However, the OCS HQ for the eagle based on refined concentrations of methylmercury and a LOAEL TRV was less than 1 indicating that potential risk to piscivorous bird populations is not expected.

<u>Total Cumulative Risk Summary (Baseline+3-Unit+OCS)</u>

- Aquatic Community and Benthic Community - maximum and refined HQs were below 1 based on COPEC concentrations in surface water (dissolved) and sediment. The maximum and refined HQ exceeded 1 for selenium (HQ=6) based on total surface water concentration, however all refined HQs were less than 1 for the remaining COPECs. 3-Unit and OCS do not appreciably contribute to risk estimates. With the exception of selenium, risk is not expected for aquatic community direct contact surface water or direct contact of benthic community to sediment.
- Adult Non-Special Status Fish - maximum total cumulative HQs using modeled fish tissue ranged from 0.01 to 1, which was contributed to almost entirely from baseline with an appreciable contribution of methylmercury from OCS (HQ=0.9). Maximum and refined measured mercury and selenium CBR HQs exceeded 1 for individual fish species, with refined HQs ranging from 2 to 3 for some fish species, with an appreciable contribution from OCS (HQ=0.5). However, refined CBR HQ were less than or equal to 1 based on the average of all fish species evaluated suggesting risk to the fish community as a whole may be acceptable, although the potential for risks from mercury and selenium cannot be ruled out for certain species of fish in the Southwest Gap Region.
- Special Status Species Fish - CBR mercury HQs were below 1 for each fish species evaluated with the exception of razorback sucker (HQ=5 using maximum tissue concentration, and HQ=3 using refined tissue concentration for the surrogate, flannelmouth sucker) for baseline alone but maximum and refined OCS CBR HQs were greater than to 1 for mercury (HQ=4 maximum, and HQ=2 refined) for each of the special status fish species evaluated, indicating an appreciable contribution to risk from OCS. Maximum and refined OCS CBR HQs were less than 1 for all other COPECs. The potential for risk from mercury for all sources combined cannot be ruled out.
- Aquatic-Oriented Non-Special Status Representative Wildlife – HQs exceeded 1 for all avian receptors evaluated using maximum and refined concentrations and NOAEL TRVs for methylmercury (refined HQ range from 3 to 5) only, with OCS contributing appreciably to the total cumulative risk estimate. However, refined HQs for birds using LOAEL TRVs were less than 1 for methylmercury indicating that risk is not expected for bird populations. For mammals, HQs exceeded 1 using maximum and refined concentrations and NOAEL TRVs for methylmercury for muskrat and raccoon (refined HQ=2) and selenium for all mammalian receptors (range of HQ 2-3). Total cumulative risk estimates for mammals are due primarily to baseline conditions. The methylmercury refined HQs for mammals were less than 1 based on LOAEL TRVs, however all LOAEL-based HQs for selenium (HQ=2 for each mammalian receptor) exceeded 1, indicating a potential for risk for herbivorous, omnivorous and insectivorous mammal populations.

For the Southwest Gap Region Study Area, potential future NGS operation scenarios (3-Unit Operation, 2-Unit Operation, or A1400) or OCS combined with baseline resulted in HQs >1 for some receptor-COPEC pairings although current baseline conditions were typically the primary source for most of the reported risk.

San Juan River ERA

The San Juan River ERA evaluated the potential for risk to aquatic and aquatic-oriented wildlife ecological receptors from exposure to chemicals associated with NGS and regional/global emissions and deposition. Baseline, future NGS operations and OCS scenarios were evaluated for a number of ecological receptors based on exposure to surface water and sediment and exposure via the food chain. The San Juan River and associated riparian corridor that comprise the San Juan study area are known to support various aquatic-oriented wildlife species and aquatic plant and animal communities, and representative receptors were selected from among plant and animal groups known or expected to occur regionally, including special status (State and/or Federally Species listed as threatened or endangered). The COPEC evaluated for the San Juan River ERA included arsenic, mercury, methyl mercury and selenium only (**Table 3RA-2**). **Table 3RA-3** presents a concise summary of the receptors, assessment and measurement endpoints and media of concern for the San Juan River ERA.

Based on the results of the San Juan River ERA, population, community, and ecosystem level risk to aquatic, benthic and aquatic-oriented species, including special status species, are unlikely as a result of baseline, NGS emissions and other sources. The baseline and future risks within the San Juan River Study Area are provided in **Table 3RA-8** and can be summarized as follows. The reader is referred to the San Juan River ERA (Ramboll Environ 2016b) for full detail regarding results).

Baseline Risk Summary

- Aquatic Community and Benthic Community - refined HQs were below 1 for dissolved COPEC concentrations in surface water and sediment. Risk not expected based on direct contact of aquatic community to surface water or direct contact of benthic community to sediment.
- Early Life Stage (ELS) Fish - CBR HQs using maximum concentrations exceeded 1 for arsenic (HQ=5), however ELS CBR HQ for arsenic was below 1 using refined concentrations. Risk is not expected.
- Adult Non-Special Status Fish - CBR HQs using maximum modeled concentrations exceeded 1 for mercury (HQ=7), however refined CBR HQs were below 1. CBR HQs using literature-based measured fish tissue concentrations were below 1 using maximum and refined baseline concentrations except for speckled dace for selenium (maximum HQ=2). Refined selenium CBR HQ for speckled dace was below 1. Risk is not expected.
- Special Status Species Fish – refined CBR HQs using measured and surrogate fish tissue concentrations were 1 or below 1 for each species evaluated. Risk is not expected.
- Aquatic-Oriented Non-Special Status Representative Wildlife - HQs exceeded 1 for the muskrat (HQ=2) and mallard (HQ=2) exposed to selenium, and for the mallard (HQ= 2) exposed to methyl mercury using maximum concentrations and NOAEL TRVs. However, refined HQs for all COPEC-receptor pairs were below 1. Risk is not expected.
- Aquatic-Oriented Special Status Species Wildlife - HQs for the special status southwestern willow flycatcher and western yellow-billed cuckoo were below 1 using maximum and refined concentrations and NOAEL TRVs. Risk is not expected.

3-Unit and OCS Risk Summary

Future 3-Unit contributions from NGS and OCS (separately and in combination) do not pose risk to the aquatic community, benthic community, fish, or bird and mammal populations, including special status species, as all maximum and refined HQs were less than 1 for all receptors. Risk from future sources alone is not expected.

Total Cumulative Risk Summary (Baseline+3-Unit+OCS)

- Aquatic Community - maximum dissolved surface water HQs exceeded 1 for dissolved (filtered) mercury (HQ=2) and total (unfiltered) selenium (HQ=3). HQs using refined concentrations of COPECs in surface water were below 1. Risk is not expected.
- Adult Non-Special Status Fish – CBR HQs based on maximum concentrations exceeded 1 for mercury only (HQ=7) for modeled tissue, and selenium only (HQ=2) based on measured tissue. CBR HQs using refined COPEC concentrations modeled or measured in fish tissue were below 1. Risk is not expected.
- Special Status Species Fish - All CBR HQs using refined COPEC concentrations were below 1. A maximum HQ greater than 1 was shown in the total cumulative evaluation using maximum

COPEC concentrations only: Colorado pikeminnow exposed to mercury (HQ=2). Risk is not expected. Note that for the Colorado pikeminnow, potential risk is possible based consideration of surrogate fish tissue data results. Because the measured tissue data were obtained from stocked fish, there is some uncertainty in the pikeminnow tissue results as it may be assumed that tissue concentrations of stocked fish may not be in equilibrium with the San Juan River ecosystem and therefore may underestimate risk. However, the level of underestimation however is likely to be low.

- Aquatic-Oriented Special Status Species Wildlife - maximum and refined total cumulative risk HQs were below 1for the willow flycatcher and yellow-billed cuckoo. Risk is not expected.
- Aquatic-Oriented Non-Special Status Representative Wildlife - total cumulative HQs using maximum COPEC concentrations and NOAEL TRVs exceeded for the mallard (HQ=2) and muskrat (HQ=2) exposed to selenium and the mallard exposed to methyl mercury (HQ=3), all total cumulative risk HQs using refined concentrations of COPECs were below 1 for all COPEC-receptor pairs. Risk is not expected.

2-Unit and Other Cumulative Sources Risk Summary

- Similar to 3-Unit Operation results, the contribution to risk from 2-Unit Operation alone and in combination OCS does not pose risk to ecological receptors evaluated for the San Juan River study area.

Total Cumulative Risk Summary (Baseline+3-Unit+OCS, 2045-2074)

- Special Status Species Fish – maximum total cumulative fish CBR HQs for the residual period (2045–2074) for mercury were 1 or below 1 (HQ=1, Colorado pikeminnow). All refined HQs were below 1.
- Aquatic-Oriented Special Status Species Wildlife – all maximum total cumulative HQs were below 1.

Kayenta Mine ERA

The Kayenta Mine ERA evaluated the potential for risk to ecological receptors from exposure to chemicals associated with mine operations and regional/global emissions and deposition. Baseline, future emissions based on future NGS operations (3-Unit, 8.1 million tons per year and 2-Unit, 5.5 million tons per year) and OCS scenarios were evaluated for a number of ecological receptors based on exposure to soil, surface water and sediment and exposure via the food chain. The proposed KMC study area is known to support various wildlife species and plant and animal communities, and representative receptors were selected from among plant and animal groups known or expected to occur regionally, including three special status species (state and/or federally listed as threatened or endangered) birds. **Table 3RA-3** presents a concise summary of the receptors, assessment and measurement endpoints and media of concern evaluated for the proposed KMC ERA.

Based on the results of the KMC ERA, population, community and ecosystem level risk to terrestrial, aquatic, benthic and aquatic-oriented species, including special status species, are unlikely as a result of baseline, KMC emissions (and NGS emissions at KMC) and other sources. The baseline and future risks within the proposed KMC Study Area are provided in **Table 3RA-9** and can be summarized as follows. The reader is referred to the KMC ERA (Ramboll Environ 2016d) for full detail regarding results.

Baseline Risk Summary

- The *KMC Sampling Investigation Report* (Ramboll Environ 2016f) indicated that concentrations of key COPECs in soil are consistent with or below background concentrations for the State of Arizona, including those within a 150 km radius of KMC.
- Terrestrial Soil Communities - refined HQs based were less than or equal to 1 for soil invertebrates and terrestrial plants, including the special status plant Navajo sedge. Risk is not expected.
- Terrestrial Non-Special Status Representative Wildlife - HQs exceeded 1 for the American robin (vanadium HQ=2) only using maximum concentrations and NOAEL TRVs. However, refined HQ for robin was equal to 1 (and the soil concentration on which the HQ was based was within the range of soil background). Risk is not expected.
- Terrestrial and Aquatic-Oriented Special Status Wildlife - HQs for the special status bird species (willow flycatcher and yellow-billed cuckoo) were below 1 using maximum and refined COPEC concentrations, and less than or equal to 1 for the Mexican spotted owl (HQ=1, methylmercury). However, refined HQs for all COPEC-receptor pairs were below 1. Risk is not expected.
- Aquatic Community (Ponds, Springs, and Washes) – for ponds, maximum dissolved surface water HQs exceeded 1 for dissolved (filtered) cadmium (HQ=10), manganese (HQ=20) and zinc (HQ=2) and total (unfiltered) aluminum (HQ=400) and selenium (HQ=5). HQs using refined concentrations of COPECs in surface water had HQs greater than 1 for: dissolved (filtered) cadmium (HQ=2) and manganese (HQ=4); and total (unfiltered) aluminum (HQ=200) and selenium (HQ=3). All other COPECs had HQs below 1. Similar results were noted for springs and washes. While HQs greater than 1 are noted in these water bodies, risk is not expected as surface water concentrations are consistent with local hydrogeologic conditions suggesting aquatic community tolerance: background conditions are a contributing factor to each COPEC, in some cases accounting for 100% of the reported HQ. Furthermore, the springs used as background sites (not influenced by mining activities) showed comparable detections and results as other spring and non-spring sites. Risk is not expected.
- Benthic Macroinvertebrates Community - refined HQs were below 1 for COPEC concentrations in sediment. Risk not expected based on direct contact of benthic community to sediment.
- Early Life Stage (ELS) Fish - CBR HQs using maximum and refined concentrations were below 1. Risk is not expected.
- Adult Non-Special Status Fish - CBR HQs using maximum and refined modeled concentrations were below 1. Risk is not expected

8.1 MTPY and OCS Risk Summary

Future 8.1 MTPY contributions from KMC (and NGS at KMC) and OCS (separately and in combination) do not pose risk to the terrestrial community, aquatic community, benthic community, fish, or terrestrial and aquatic bird and mammal populations, including special status species. Although the maximum HQ for iron exceeded 1 for the aquatic community in KMC ponds, washes and springs (HQ=3, iron), refined HQs were less than 1 for all receptors. Risk from future sources alone is not expected.

Total Cumulative Risk Summary (Baseline+8.1 MTPY+OCS)

- Terrestrial and Aquatic-Oriented Special Status Plants and Wildlife – Baseline and future emissions from 8.1 MTPY and OCS, both alone and in combination, indicated that conditions do not pose unacceptable risks to special status species, including the Navajo sedge, Mexican spotted owl, western yellow-billed cuckoo, and the southwest willow flycatcher.

- Terrestrial Soil Communities – Baseline and future emissions from 8.1 MTPY and OCS, both alone and in combination, do not pose unacceptable risks to terrestrial plants or soil invertebrates

- Terrestrial and Aquatic-Oriented Non-Special Status Representative Wildlife – Baseline and future emissions from 8.1 MTPY and OCS, both alone and in combination, do not pose unacceptable risks to terrestrial or aquatic oriented bird and mammal populations as all refined HQs were less than or equal to 1.

- Aquatic Community, Fish and Benthic Community – refined HQs for sediment-dwelling invertebrates and fish communities were less than 1 indicating that risk is not expected. While aquatic community risk estimates exceeded 1 for some metals based on refined results in ponds, springs and/or washes (base flow) risk is not expected due to species tolerance to the naturally-occurring hydrogeologic conditions of the area.

5.5 MTPY and Other Cumulative Sources Risk Summary

- Baseline and the 5.5 MTPY, alone and in combination, did show some HQ values above 1 for various receptors, particularly aquatic community receptors for iron. However, the aquatic community results were overly conservative. Risk is not expected.

- The potential influence of NGS on KMC was conducted as part of the ERA. The results of “NGS at KMC” indicated that any contributions from NGS would have a *di minimis* effect on the risk estimates presented for ecological receptors in the KMC study area.

1.4.4 Key Uncertainties

The uncertainty analysis of the ERAs included discussion of uncertainties related to interpretation of risk characterization results per risk assessment guidance (USEPA 1997). In general, risk assessments are designed to deliberately be conservative to avoid missing potential ecological risk. Because of these assumptions and estimates, the results of the risk calculations are themselves uncertain. It is important to keep this in mind when interpreting the results of a given risk assessment. Quantitative evaluation of ecological risks is frequently limited by uncertainty (lack of knowledge) regarding data, exposure, toxicity, and risk issues The uncertainty analysis provides a description of the nature of the uncertainties encountered in developing the ERA and is an integral part of the risk assessment process (USEPA 1997). Although risk assessment follows a formal scientific approach, making assumptions or estimates based on limited data or by incorporating professional judgment is an inherent part of the process. Uncertainties built into the estimation of exposures and risks may act either to increase or decrease the identified risks, depending on the source of uncertainty. Common sources of uncertainty include those related to the development of the CSM, the factors used to develop the risk estimate (e.g., exposure assumptions and toxicity assumptions), and uncertainty in the parameters used to evaluate risk (e.g., data gaps, exposure point estimates). The general sources of uncertainty and the potential impact on the assessment are presented in **Table 3RA-10**. Site-specific uncertainties that were identified in the ERAs are presented below.

- The potential influence of KMC on the NGS Near-field and NGS Gap Region areas – This is an uncertainty because the KMC influence was not quantitatively evaluated. However, there is sufficient information to conclude that the influence from KMC would be *de minimis* and would not alter the conclusions in the NGS Near-field or NGS Gap Region ERAs.

- Use of maximum detected concentrations and generic benchmarks in the screening evaluation overestimates potential exposures and therefore, results in an overestimate of potential risks. Screening values are typically based on the low end of available benchmarks from multiple valid sources which may range over an order of magnitude.

- Critical Body Residue used for mercury in the food web model – Both NOEC and LOEC CBRs are typically used to assess potential risk because the NOEC CBRs represent the reasonable worst case measure of effect and LOEC CBR provides a realistic measure of effect. However, there are hundreds of available mercury CBRs in the literature ranging in concentration over several orders of magnitude and cover a variety of endpoints including behavioral, histological, developmental, reproductive, growth and survival.
- Except for methylmercury, the bioconcentration factors (BCFs) used to estimate fish tissue concentrations are based on literature values. The use of site-specific data to derive the BCF for methylmercury is appropriate to address uptake via all routes of exposure (uptake from gills and diet). However, the site-specific BCF exceeded BCFs found in the literature by 1 to 2 orders of magnitude resulting in an uncertainty.
- Estimates of media concentrations for the future operations scenarios that are used in the intake equations – Uncertainty can be introduced into a risk assessment when modeling the fate and transport of pollutants in a variety of different and variable environments, by processes that are often poorly understood or too complex to quantify accurately (USEPA 2005). Computer models such as AERMOD used to predict maximum air concentrations and deposition rates typically result in a magnitude of error ranging from 10 to 40%.
- Individual versus population level impacts using HQs – HQs provide insight into the types of impacts an individual organism may experience but they do not provide the same level of insight into population impacts.
- Interactions of multiple stressors – While toxicity of multiple compounds is assumed to be additive, chemicals having different modes of action exhibit sub-additive toxicity.
- Tolerance and adaptation – Not considered directly even though it is well known that biological organisms have the capacity to tolerate a variety of conditions and adapt to an environment when exposed on a long-term basis.
- Absorption factors – The food web model assumes that 100% of the constituent consumed by an organism is taken up from the digestive system and that none of the constituent is excreted ((100% bioavailable). Using an absorption factor of 1 result in an overestimate of risk.
- Diet – Diet proportions for receptors can be a source of uncertainty as there are many factors that contribute to feeding preferences including seasonal use, availability, opportunity etc.
- Constituents not detected (e.g., hexavalent chromium, acrolein and benzene at Near-field, selenium and antimony at KMC), infrequently detected (e.g., cyanide at Near-field), or not included quantitatively in the ERA (e.g., thallium because of limited criteria), result in uncertainties.

1.4.4.1 Quality Assurance

The overall approach and calculations performed and presented in the Ramboll Environ ERAs (Ramboll Environ 2016a,b,c,d), as well as the human health risk assessments (Environ 2015; Ramboll Environ 2016e), were reviewed by AECOM for quality assurance purposes. The draft risk assessments were reviewed to assure:

- Satisfactory Work or Study Plan Implementation – the risk assessments were reviewed to assure satisfactory implementation of the risk assessment work/study plan, assuring that the risk assessments are compliant with the overall approach as specified in the respective work and study plans. Based on review of the documents, the risk assessments were implemented as specified.
- Accuracy of risk calculations – a representative subset of risk calculations were reviewed using the chemical-, receptor- and site-specific input variables presented in the draft risk assessments. The calculation quality assurance review was reviewed by USBR and OSMRE to satisfy

questions regarding the calculations. Based on this review, the calculations were found to be reproducible using the inputs and equations/models presented in the documents.

- Reporting Accuracy – the draft ERAs and HHRAs were distributed to the ERA and HHRA subgroups for review and comment. Comments to the draft documents are being compiled at present and will be presented to the authors for consideration. Substantive issues, if any, would be addressed and implemented into the Final ERA and HHRA documents.

The above quality assurance elements were included to verify the reported results for implementation into the EIS. Reviews were conducted by experienced risk assessment practitioners. Mr. Kenneth Pinnella (senior ecological and human health risk assessor) was the EIS technical resource lead for risk assessment and was supported by Ms. Christine Archer (senior ecological risk assessor), Ms. Melissa Paliouras (ecological risk assessor, and support to Ms. Archer), Mr. James Knight (ecological risk assessor), and Ms. Meegan Zimmerman (senior human health risk assessor).

1.5 References

Allard, P., A. Fairbrother, B. K. Hope, R. N. Hull. M. S. Johnson, L. Kapustka, G. Mann, B. McDonald, and B. E. Sample. 2009. Recommendations for the Development and Application of Wildlife Toxicity Reference Values. Integrated Environmental Assessment and Management 6(1):28-37.

Arizona Department of Environmental Quality. 2009. Water Quality Standards for Surface Waters. Internet website: http://www.azdeq.gov/environ/water/standards/. Accessed August 10, 2016..

Beckvar N., T. M. Dillon, and L. B. Read. 2005. Approaches for Linking Whole-body Fish Tissue Residues of Mercury or DDT to Biological Effects Thresholds. Environmental Toxicology and Chemistry 24(8):2094-2105.

Buchman, M. F. 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1, Seattle, Washington. Office of Response and Restoration Division. National Oceanic and Atmospheric Administration, 34 pp.

Eagles-Smith, C. A., J. J. Willacker, Jr., and C. M. Flanagan Pritz. 2014. Mercury in Fishes from 21 National Parks in the Western United States - Inter and intra-Park Variation in Concentrations and Ecological Risk: U.S. Geological Survey Open-File Report 2014-1051, 54 p. http://dx.doi.org/10.3133/ofr20141051 .

Efroymson, R. A., M. E. Will, G. W. Suter, II, and A. C. Wooten. 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. ES/ER/TM-85/R3. Oak Ridge, Tennessee. Oak Ridge National Laboratory.

Efroymson, R. A., M. E. Will, and G. W. Suter, II. 1997b. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision. ES/ER/TM-126/R2. Oak Ridge, Tennessee. Oak Ridge National Laboratory.

Electric Power Research Institute (EPRI). 2016. A Case Study Assessment of Trace Metal Atmospheric Emissions and their Aquatic Impacts in the San Juan River Basin. Phase 2: Navajo Generating Station. 3002006244. R. Goldstein and L. Levin. Final Report. April 2016.

Environ. 2015. Memorandum: Summary of Approach to Assess NGS Gap Regions. May 8, 2015.

Environ. 2014a. Near-field Air Dispersion and Deposition Modeling Protocol for Navajo Generating Station National Environmental Policy Act Environmental Impact Statement and Endangered Species Act Compliance. Draft Report prepared for Salt River Project. April 2014.

Environ. 2014b. Near-Field Field Sampling Plan. Salt River Project-Navajo Generating Station, Page, Arizona. Revision 1. July 2014.

Hart, R. J., H. E. Taylor, and G. M. Anderson. 2012. Establishment of Sentinel Sampling Sites to Monitor Changes in Water and Sediment Quality and Biota Related to Visitor Use at Lake Powell, Arizona and Utah, 2004–2006: U.S. Geological Survey Open-File Report 2012–1237, 25 p.

Hinck et al. 2006. Biomonitoring of Environmental Status and Trends (BEST) 2003 Large River Monitoring Network Fish Tissue Samples. January 13, 2010.

Hinck, J. E., V. S. Blazer, N. D. Denslow, T. S. Gross, J. J. Coyle, T. W. May, C. E. Orazio, and D. E. Tillitt. 2003. Contaminant Concentrations and Biomarker Response of Piscivorous and Benthivorous Fish in the Colorado River Basin.

Jarvinen, A. W. and G. T. Ankley. 1999. Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals. SETAC Technical Publication Series.

Kepner, W. G. 1988. Memorandum from U.S. Fish and Wildlife Service, Ecological Services. Analytical Request – Little Colorado River with Tracking Form for Contaminant Analysis of Biological and Bottom Sediment Samples from the Little Colorado River in Grand Canyon National Park. Phoenix, Arizona. June 16, 1988.

Los Alamos National Laboratory (LANL). 2012. Ecorisk Database (Release 3.1). Internet website: http://www.lanl.gov/community-environment/environmentalstewardship/protection/eco-risk-assessment.php. Accessed June 3, 2016.

Lusk, J. 2010. Mercury (Hg) and Selenium (Se) in Colorado Pikeminnow and in Razorback Sucker from the San Juan River. USFWS Presentation to San Juan RIP, Biology Committee Meeting, January 13, 2010.

Lusk, J. D. 2010. Mercury (Hg) and Selenium (Se) in Colorado Pikeminnow and in Razorback Sucker from the San Juan River. U.S. Fish and Wildlife Service, New Mexico Ecological Services. Presentation to San Juan RIP, Biology Committee Meeting, January 13, 2010.

Lusk, J. D. E. Rich, and R. S. Bristol. 2005. Methylmercury and Other Environmental Contaminants in Water and Fish Collected from Four Recreational Fishing Lakes on the Navajo Nation, 2004. Prepared for the Navajo Nation Environmental Protection Agency, Window Rock, Arizona. Completion Report for Intergovernmental Agreement No. C23313 and U.S. Fish and Wildlife Service Agreement No. 1448-20181-03-J817.

MacDonald D. D., C. G. Ingersoll, and T. A. Berger. 2000. Development and Evaluation of Consensus Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology 39(1):20-31.

McVehil-Monnett Associates, Inc. (MMA). 2016. Kayenta Mine Complex Air Quality Modeling Analyses (Final draft). Report to Peabody Energy. 353 pp. January.

Navajo Nation Environmental Protection Agency. 2004. Navajo Nation Surface Water Quality Standards. Prepared by: Navajo Nation Environmental Protection Agency, Water Quality Program. Window Rock, Arizona. Passed by Navajo Nation Resources Committee on July 30, 2004.

New Mexico Water Quality Control Commission. 2012. Standards for Interstate and Intrastate Surface Waters.

Olsen, A. R., B. D. Snyder, L. L. Stahl, and J. L. Pitt. 2009. Survey Design for Lakes and Reservoirs in the United States to Assess Contaminants in Fish Tissue. Environmental Monitoring and Assessment (2009) 150:91-100.

Ramboll Environ. 2016a. DRAFT FINAL NGS Near-field Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. Version 2. March 2016.

Ramboll Environ. 2016b. DRAFT FINAL NGS San Juan River Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. April 2016.

Ramboll Environ. 2016c. DRAFT FINAL NGS Gap Region Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. March 2016.

Ramboll Environ. 2016d. DRAFT FINAL Ecological Risk Assessment, Environmental Impact Statement Ecological Risk Assessment Report for the Kayenta Mine Complex. April 2016.

Ramboll Environ, 2016e. NGS Sampling Investigation Report, Salt River Project- Navajo Generating Station. Near-Field Investigation Report, Revision 1 FINAL. March 2016.

Ramboll Environ. 2016f. NGS Sampling Investigation Report, Salt River Project- Navajo Generating Station. Near-field Investigation Report, Revision 1 FINAL. March 2016.

Ramboll Environ. 2016g. KMC Sampling Investigation Report, Salt River Project- Navajo Generating Station. KMC Sampling Investigation Report, Revision 2 FINAL. April 2016.

Sample, B. E., D. M. Opresko, and G. W. Suter, II.1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, Tennessee. June 1996. ES/ER/TM-86/R3.

Simpson, Z. R. and J. D. Lusk. 1999. Environmental Contaminants in Aquatic Plants, Invertebrates, and Fishes of the San Juan River Mainstem, 1990-1996. Prepared for the San Juan River Recovery Implementation Program. U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office. Albuquerque, New Mexico. October 26, 1999.

Suter, G. W. and C. L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Prepared by Risk Assessment Program, Health Sciences Research Division, Oak Ridge, Tennessee. Prepared for the U.S. Department of Energy, Office of Environmental Management under Budge and Reporting Code EW20.

U.S. Environmental Protection Agency (USEPA). 2015. Draft Aquatic Life Ambient Water Quality Criterion for Selenium (Freshwater) – 2015. EPA 822-P-15-001. Office of Water, Office of Science and Technology, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 2013. ProUCL version 5.0. Office of Research and Development, National Exposure Research Laboratory, Las Vegas Nevada. Internet website: http://www.epa.gov/osp/hstl/tsc/PrpUCL_v5.0_user.pdf . Accessed August 10, 2016.

U.S. Environmental Protection Agency (USEPA). 2009a. Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). Final. January 2009.

U.S. Environmental Protection Agency (USEPA). 2009b. USEPA Region 9 Biological Technical Assistance Group (BTAG) Recommended Toxicity Reference Values for Birds. Revision Date 02/24/09.

U.S. Environmental Protection Agency (USEPA). 2007. Ecological Soil Screening Levels for Selenium: Interim Final. OSWER Directive 9285.7-72, Revised. March.

U.S. Environmental Protection Agency (USEPA). 2007c. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Attachment 4-5 Eco-SSL Standard Operating Procedure (SOP) #6: Derivation of Wildlife Toxicity Reference Value. OSWER Directive 9285.7-55. Revised June.

U.S. Environmental Protection Agency (USEPA). 2006. Region III Biological Technical Assistance Group Freshwater Sediment Screening Benchmarks. Internet website: http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm. Accessed August 9, 2016.

U.S. Environmental Protection Agency (USEPA). 2005. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Final EPA 520-R-05-006: Solid Waste and Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 2002. USEPA Region 9 Biological Technical Assistance Group (BTAG) Recommended Toxicity Reference Values for Mammals. Revision Date 11/21/02.

U.S. Environmental Protection Agency (USEPA). 2001. The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments. OSWER, Eco Update. Publication 9345.0-14, EPA 540/ F-01/014. June.

U.S. Environmental Protection Agency (USEPA). 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (Volume One). EPA 530-D-99-001A. Office of Solid Waste, Washington, D.C. August 1999.

U.S. Environmental Protection Agency (USEPA). 1998. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, Washington, D.C. EPA/630/R-95/002F. April.

U.S. Environmental Protection Agency (USEPA). 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments: Interim Final. OSWER 9285.7-25, EPA 540-R-97-006. June.

U.S. Environmental Protection Agency (USEPA). 1994. Assessment and Remediation of Contaminated Sediments (ARCS) Program. Assessment Guidance Document. Great Lakes National Program Office. July.

U.S. Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development; Washington, D.C. EPA/600-R/R-93/187a,187b.

U.S. Fish and Wildlife Service (USFWS). 2014. National Wild Fish Health Survey. http://www.fws.gov/wildfishsurvey/ (Accessed October 2014).

U.S. Fish and Wildlife Service (USFWS). 1986. Monitoring Fish and Wildlife for Environmental Contaminants: The National Contaminant Biomonitoring Program. Internet website: http://www.cerc.usgs.gov/pubs/center/pdfDocs/90341.PDF. Accessed August 7, 2016.

Utah Department of Environmental Quality-Division of Water Quality. Internet website: 2008. http://www.deq.utah.gov/Compliance/monitoring/water/Data.htm . Accessed June 1, 2014.

Walters, D. M. E. Rosi-Marshall, T. A. Kennedy, W. F. Cross, and C. V. Baxter. 2015. Mercury and Selenium Accumulation in the Colorado River Food Web, Grand Canyon, USA. Environmental Toxicology and Chemistry 34(10):2385-2394.

Tables

This page intentionally left blank

Table 3RA-1 Chronology of Key Milestones and Documents in Development of the Ecological and Human Health Risk Assessments

Doc No.	Document/ Milestone Name	Document/ Milestone Type	Deliverable	Document Title	Description	Date
1	NGS Near-Field Field Sampling Plan	Planning	DRAFT NGS FSP 2014 06 12e	Field Sampling Plan Salt River Project- Navajo Generating Station, Revision 0	NGS field sampling plan for area within 20 km of NGS (NGS Near-Field study area)	12-Jun-14
1	NGS Near-Field Field Sampling Plan	Planning			Comments to draft NGS FSP compiled and provided to Environ/SRP	25-Jun-14
1	NGS Near-Field Field Sampling Plan	Planning			Web-Ex call-in meeting presented by ENVIRON regarding Comments to the Draft SRP-NGS Field Sampling Plan (FSP) and attended by the Ecological Risk Assessment Subgroup to discuss resolve outstanding issues	2-Jul-14
1	NGS Near-Field Field Sampling Plan	Planning			Envrion/SRP provide response to comments regarding Draft NGS FSP	7/18/2014
1	NGS Near-Field Field Sampling Plan	Planning	NGS FSP -Revision 1 Final Text-Tbs-Figs-No Appendices (2014 07 17); NGS FSP -Revision 1 Final Appendices (2014 07 17)	Field Sampling Plan Salt River Project- Navajo Generating Station, Revision 1	Final NGS Near-Field FSP received	7/25/2014
2	NGS Near-Field Sampling Investigation Report	Reporting	SRP Near-Field IR Rev 0_2015 5 18_all (Agency Review Draft)	NGS Near-Field Sampling Investigation Report, Revision 0	Soil, sediment and surface water data collection and analytical chemistry results obtained per NGS field sampling plan for area within 20 km of NGS	22-May-2015
2	NGS Near-Field Sampling Investigation Report	Reporting			Provided Draft SIR to ESA subgroup for review/comment	28-May-2015
2	NGS Near-Field Sampling Investigation Report	Reporting			Provided reviewer comments to Envrion/SRP	23-Sep-2015
2	NGS Near-Field Sampling Investigation Report	Reporting	NGS Near-Field Sampling Investigation Report (app A-D and G) - Final	FINAL NGS Sampling Investigation Report Salt River Project-Navajo Generating Station, Revision 1	Final NGS Near-Field Sampling Investigation Report received, including all appendices (Appendix E, data validation reports) and response to comments	28-Mar-2016
3	NGS Near-field ERA Study Plan	Planning	NGS_Project_ERA_Study Plan_May02_2014		Ecological risk assessment work plan for NGS near-field ecological risk assessment; initial draft provided by Environ for internal review	2-Jun-14
3	NGS Near-field ERA Study Plan				received written comments on the ERA Study Plan and distributed to Environ for response and implementation of comments.	18-Jun-14
3	NGS Near-field ERA Study Plan				held web-ex presentation to discuss comments - revisions to the ecological risk assessment protocol to be made pending consideration of field sampling results (per the Near-Field Field Sampling Plan - sampling to be conducted in July/August 2014).	2-Jul-14
3	NGS Near-field ERA Study Plan	Planning	Final NGS Near Field ERA Study Plan 05 07 2015b		revised draft final Near-Field ERA Study Plan received from SRP for final review/comment	15-May-15
3	NGS Near-field ERA Study Plan	Planning			Final Near-field ERA protocol distributed to ESA subgroup	29-May-15
4	Gap Region Memo	Planning	DRAFT Gap Region Memo 08 21 2014c		Ecological risk assessment work/study plan for Gap regions area ecological risk assessment. Initial draft provided by Environ for internal review and distributed for comment to ERA subgroup	21-Aug-2014
4	Gap Region Memo	Planning	DRAFT Gap Region Memo 08 21 2014c Response to Comment		AECOM received written comments on the Gap Region Memo and distributed to Environ for response to comment.	September/October 2014
4	Gap Region Memo	Planning			ENVIRON discussed the comments with the ESA subgroup in September and revised the Gap Memo according to reviewer comments. Environ provided written response to comments	November/December 2014
4	Gap Region Memo	Planning	DRAFT Revised Gap Region Memo 01 06 2015b		Revised memo per the written response to comments provided to ERA subgroup for final review/comment	6-Jan-2015
4		Planning	FINAL Gap Region Memo 05 08 2015		Final Gap Region Memo received	15-May-2015

Table 3RA-1 Chronology of Key Milestones and Documents in Development of the Ecological and Human Health Risk Assessments

Doc No.	Document/ Milestone Name	Document/ Milestone Type	Deliverable	Document Title	Description	Date
5	EPRI Study	Reporting	Summary of Results EPRI San Juan River Basin Project: Navajo Generating Station Study		Summary of EPRI air modeling data and reporting	10-Apr-15
5	EPRI Study	Reporting	EPRI San Juan Basin Rpt Phase 2 NGS DRAFT FINAL		EPRI air modeling data and reporting	January 2016
6	NGS San Juan River ERA Study Plan	Planning	NGS SJR ERA Study Plan May 2 2014	DRAFT San Juan River Ecological Risk Assessment Study Plan for National Environmental Policy Act Environmental Impact Statement and Endangered Species Act Compliance	Ecological risk assessment work plan for San Juan River ecological risk assessment; Draft Study plan submitted for review/comment	2-May-14
6	NGS San Juan River ERA Study Plan	Planning			received written comments on the SJR Study Plan from ESA subgroup and distributed to Environ for response.	June 2014
6	NGS San Juan River ERA Study Plan	Planning			Envrion revision to SJR Study Plan per comments in process; completion subject to input and general comments received on the ERA Near-Field Protocol document being completed concurrently.	31-Dec-14
6	NGS San Juan River ERA Study Plan	Planning	FINAL NGS SJR ERA Study Plan 06 05 2015	San Juan River Ecological Risk Assessment Study Plan for National Environmental Policy Act Environmental Impact Statement and Endangered Species Act Compliance, FINAL	Final SJR ERA Study Plan received	5-Jun-15
7	NGS San Juan River ERA	Reporting	SJR Region EIS Summary 12 05 2015		Interim SJR Ecological Risk Assessment results summary to support EIS development	6-Dec-16
7	NGS San Juan River ERA	Reporting	SJR Region EIS Summary 02 11 2016c		Revised, Interim SJR Ecological Risk Assessment results summary to support EIS development	13-Feb-16
7	NGS San Juan River ERA	Reporting	SJR ERA Report 04 02 2016	Draft Final NGS San Juan River Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station	Draft Final ERA received	4-Apr-16
7	NGS San Juan River ERA	Reporting			AECOM providing comment for consideration for inclusion in final ERA	in process
8	NGS Near Field ERA	Reporting	Draft NGS Baseline EIS Summary 08 11 2015	DRAFT NGS Near-Field Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station	Interim document received for review of ERA input parameters	12-Aug-2015
8	NGS Near Field ERA	Reporting			Provided comments from ESA subgroup to Environ/SRP regarding draft interim document	4-Jan-2016
8	NGS Near Field ERA	Reporting	NGS BL+B2+OCS EIS 10 23 2015d	DRAFT NGS Near-Field Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station, Version 1 October	Interim Ecological Risk Assessment results summary to support EIS development	28-Oct-2015
8	NGS Near Field ERA	Reporting	Draft NGS Near Field ERA BL_B2_A1_A1400_OCS Summary 12 10 2015c	DRAFT NGS Near-Field Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station, Version 1 December	Interim Ecological Risk Assessment results summary to support EIS development	10-Dec-2015

Table 3RA-1 Chronology of Key Milestones and Documents in Development of the Ecological and Human Health Risk Assessments

Doc No.	Document/ Milestone Name	Document/ Milestone Type	Deliverable	Document Title	Description	Date
8	NGS Near Field ERA	Reporting	NGS Near Field ERA Draft Final Report V2 (2016 03 18)b	Draft Final NGS Near-Field Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station, Version 2 March	Draft Final ERA received, which incorporate the ESA subgroup comments provided in regard to the August 2015 interim document	21-Mar-2016
8	NGS Near Field ERA	Reporting			ERA subgroup providing comment for consideration in final ERA	in process
9	Gap Regions ERA	Reporting	NGS Gap Region EIS Summary 11 10 2015	NGS Gap Region Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station, DRAFT. November	Interim Ecological Risk Assessment results summary to support EIS development	11-Nov-2015
9	Gap Regions ERA	Reporting	NGS Gap EIS Summary BL_B2_A1_A1400_OCS 12 02 2015	NGS Gap Region Ecological Risk Assessment Environmental Impact Statement Summary Report for the Navajo Generating Station, DRAFT. December	Interim Ecological Risk Assessment results summary to support EIS development; includes all NGS scenarios/results	4-Dec-2015
9	Gap Regions ERA	Reporting	NGS Gap Region ERA Report_DRAFT FINAL 03 23 2016	Draft Final NGS Gap Region Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station	Draft Final ERA received	6-Apr-2016
9	Gap Regions ERA	Reporting			ERA subgroup providing comment for consideration in final ERA	in process
10	KMC ERA	Reporting	Draft KMC EIS Summary BL+8 1+5 5+OCS 2015 12 09 complete	Ecological Risk Assessment Environmental Impact Statement Summary Report for the Kayenta Mine Complex, DRAFT. December	Interim Ecological Risk Assessment results summary to support EIS development	10-Dec-15
10	KMC ERA	Reporting	KMC ERA Draft Final Report with Appendices (2016 04 08)d	DRAFT FINAL Ecological Risk Assessment, Environmental Impact Statement Final Report for the Kayenta Mine Complex. April	Draft Final ERA received	8-Apr-16
10	KMC ERA	Reporting			AECOM providing comment for consideration in final ERA	in process
11	KMC Field Sampling Plan ERA Addendum	Planning	SRP KMC ERA FSP Addendum 2014 10 23e (Text-Tables-Figures)x	Kayenta Mine Complex Ecological Risk Assessment Field Sampling Plan Addendum Draft, Revision 0	Addendum to the Navajo Generating Station (NGS) Sampling and Analysis Plan (SAP) comprised of a NGS Near-Field Field Sampling Plan, NGS Quality Assurance Project Plan (QAPP), and NGS Health and Safety Plan (HASP) implemented in July and August 2014	24-Oct-2014
11	KMC Field Sampling Plan ERA Addendum	Planning			Comments to draft NGS FSP compiled and provided to Environ/SRP; verbal approval to proceed with field work November 12 - 14.	11-Nov-2014
12	KMC Field Sampling Plan HHRA Addendum	Planning	KMC HHRA FSP Rev F with maps	Kayenta Mine Complex Human Health Risk Assessment Field Sampling Plan Addendum, Draft Final, Revision F	Draft KMC field sampling plan to support the human health risk assessment; prepared by Flatirons Toxicology, Inc. Addendum to the Navajo Generating Station (NGS) Sampling and Analysis Plan (SAP) comprised of a NGS Near-Field Field Sampling Plan, NGS Quality Assurance Project Plan (QAPP), and NGS Health and Safety Plan (HASP) implemented in July and August 2014	31-Oct-2014
12	KMC Field Sampling Plan HHRA Addendum	Planning			Comments to draft NGS FSP compiled and provided to Flatirons/SRP; verbal approval to proceed with field work November 12 - 14.	11-Nov-2014
13	KMC Field Sampling Report	Reporting	SRP KMC SIR Revision 0 (Agency Review Draft 2015 06 09b)	KMC Sampling Investigation Report Salt River Project- Kayenta Mine Complex, Revision 1. May 2015	Draft report for soil, sediment and surface water data collection and analytical chemistry results obtained per KMC Field Sampling Addendum for Kayenta Mine	18-Jun-2015

Table 3RA-1 Chronology of Key Milestones and Documents in Development of the Ecological and Human Health Risk Assessments

Doc No.	Document/ Milestone Name	Document/ Milestone Type	Deliverable	Document Title	Description	Date
13	KMC Field Sampling Report	Reporting			Comments to draft KMC Sampling Investigation Report compiled and provided to Environ/SRP	6-Jul-2015
13	KMC Field Sampling Report	Reporting	KMC SIR_Text-Tables-Figures-Appendix A-C&G Final (2016 04 01) Version 2	KMC Sampling Investigation Report Salt River Project- Kayenta Mine Complex. April 2016	Final report for soil, sediment and surface water data collection and analytical chemistry results obtained per KMC Field Sampling Addendum for Kayenta Mine; inclusive of response to comments provided to the field sampling plan addendum documents (HHRA addendum and ERA addendum) and comment provided to drat SIR ca. July 2015	1-Apr-2016
14	KMC ERA Study Plan	Planning	KMC Air Modeling Protocol	Draft Air Quality Modeling Protocol for the Kayenta Mine Complex. November 2014, MMA	Received Air Modeling protocol in support of the KMC ERA Study Plan being developed, prepared by MMA, from Environ/SRP	13-Nov-14
14	KMC ERA Study Plan	Planning	KMC Draft ERA Study Plan Rev 2_01 14 2015	Kayenta Mine Complex Ecological Risk Assessment Study Plan for National Environmental Policy Act Environmental Impact Statement and Endangered Species Act Compliance, Draft. January	Draft Ecological risk assessment work plan for NGS near-field ecological risk assessment	14-Jan-15
14	KMC ERA Study Plan	Planning			Provided comments on draft document from ESA subgroup to Environ/SRP	15-Feb-15
14	KMC ERA Study Plan	Planning	KMC FINAL ERA Study Plan 06 12 2015b	Kayenta Mine Complex Ecological Risk Assessment Study Plan for National Environmental Policy Act Environmental Impact Statement and Endangered Species Act Compliance, Final. June	Final ERA study plan received; inclusive of comments provided to the draft	15-Jun-15
15	NGS HHRA Work Plan	Planning	NGS HHRA work plan revised 2015_01_29	Human Health Risk Assessment Work Plan for Navajo Generating Station, National Environmental Policy Act Environmental Impact Statement, Revision 2. January	Human health risk assessment work plan for AERMOD model domain associated with NGS	29-Jan-15
15	NGS HHRA Work Plan	Planning			Comments to draft NGS FSP compiled and provided to Environ/SRP	13-Feb-15
15	NGS HHRA Work Plan	Planning			Final NGS HHRA Work Plan	in process
16	NGS HHRA Report	Reporting	NGS Baseline HHRA Results Narrative 20150616 (FINAL)	NGS HHRA Interim Results - Baseline Risk Summary Narrative	Interim human health risk assessment results summary for baseline scenario	17-Jun-15
16	NGS HHRA Report	Reporting	NGS Future B2 and KMC@NGS HHRA Results Narrative_v3_20151016	NGS HHRA Interim Results – Risk Summary Narrative for Future Project B2 Scenario and NGS-KMC Combined Scenario	Interim human health risk assessment interim results summary for B2 scenario	17-Oct-15
16	NGS HHRA Report	Reporting	NGS Future OCS HHRA Results Narrative_Final 2015.11.16	NGS HHRA Interim Results – Risk Summary Narrative for Other Cumulative Sources and Combined EIS Scenarios	Interim human health risk assessment interim results summary for other cumulative sources (OCS) and NGS scenarios	16-Nov-16
16	NGS HHRA Report	Reporting	NGS HHRA_Draft Final Report_V3_full doc 20160126	Human Health Risk Assessment Report, Navajo Generating Station. January	Draft Final human health risk assessement report for NGS	1-Jun-16
					Comments to draft NGS HHRA compiled and provided to Environ/SRP	1-Jun-16
16	NGS HHRA Report	Reporting		Final NGS Human Health Risk Assessment Report	Final NGS HHRA Report	in process
17	KMC HHRA Work Plan	Planning	KMC HHRA Work Plan Rev E	Human Health Risk Assessment Work Plan for Kayenta Mine Complex, Revision E	Human health risk assessment work plan for KMC; initial draft provided by Peabody/Flatirons Toxicology, Inc for internal review.	26-Jan-15
17	KMC HHRA Work Plan	Planning			Comments to draft NGS FSP compiled and provided to Environ/SRP	13-Feb-15

Table 3RA-1 Chronology of Key Milestones and Documents in Development of the Ecological and Human Health Risk Assessments

Doc No.	Document/ Milestone Name	Document/ Milestone Type	Deliverable	Document Title	Description	Date
17	KMC HHRA Work Plan	Planning	KMC HHRA Work Plan Final (Rev. 0) Complete	Human Health Risk Assessment Work Plan for Kayenta Mine Complex, National Environmental Policy Act Environmental Impact Statement Final (Rev. 0). June	Final HHRA work plan received for the KMC; completed by Flatirons Toxicology, inc. inclusive of comments received in February.	24-Jun-15
18	KMC HHRA Report	Reporting	KMC Prelim Baseline HHRA	KMC HHRA Preliminary Results - Baseline Risk Summary Narrative	Web-Ex call-in meeting presented by Flatirons Toxicology, Inc to provide an overview/summary of the human health risk assessment process and preliminary results. Attended by cooperating agencies.	12-Jun-15
	KMC HHRA Report	Reporting			Form HHRA subgroup for review of HHRA report	12-Aug-15
18	KMC HHRA Report	Reporting	KMC FO 8.1 NARR Rev C Rev with Attachments	KMC HHRA Preliminary Results - Future Operation (8.1) Risk Summary Narrative	Interim Human Health Risk Assessment results summary to support EIS development; includes NGS scenarios/results for 8.1 MTPY Scenario	20-Oct-15
18	KMC HHRA Report	Reporting	KMC FO 5.5 NARR REV C	Draft KMC HHRA Preliminary Results - Future Operation (5.5) Risk Summary Narrative	Interim Human Health Risk Assessment results summary to support EIS development; includes NGS scenarios/results for 5.5 MTPY Scenario	20-Oct-15
18	KMC HHRA Report	Reporting	KMC HHRA REV E DEC	Kayenta Mine Complex Human Health Risk Assessment, Revision E. December 2015	Draft final KMC HHRA report received	1-Jan-16
18	KMC HHRA Report	Reporting			HHRA subgroup providing comment for consideration in final HHRA	in process

Notes:
ERA = ecological risk assessment
HHRA = human health risk assessment
MTPY = million tones per year
EIS = environmental impact statement

Table 3RA-2 Summary of Chemicals of Potential Ecological Concern for NGS-KMC Risk Assessments

		NGS Risk Assessments			KMC Risk Assessment
COPEC	**CAS Number**	**Near -Field**	**Gap Region**	**San Juan River**	**Proposed KMC**
Inorganic Chemicals					
Aluminum	7429-90-5	x			x
Antimony	7440-36-0	x			x
Arsenic	7440-38-2	x	x	x	x
Barium	7440-39-3	x			x
Beryllium	7440-41-7	x			x
Boron	7440-42-8	x			x
Cadmium	7440-43-9	x			x
Chromium (total)	7440-47-3	x			x
Chromium VI	18540-29-9	x			
Cobalt	7440-48-4	x			x
Copper	7440-50-8	x			x
Cyanide	57-12-5	x			
Fluoride	16984-48-8	x			
Iron	7439-89-6	x			x
Lead	7439-92-1	x			x
Manganese	7439-96-5	x			x
Mercury	7439-97-6	x	x	x	x
Methylmercury	22967-92-6	x	x	x	x
Molybdenum	7439-98-7	x			x
Nickel	7440-02-0	x			x
Selenium	7782-49-2	x	x	x	x
Silver	7440-22-4	x			x
Strontium	7440-24-6	x			x
Thallium	7440-28-0	x			x
Vanadium	7440-62-2	x			x
Zinc	7440-66-6	x			x
Organic Chemicals					
2-Methylnaphthalene	91-57-6				x
Acenaphthene	83-32-9	x			x
Acenaphthylene	208-96-8	x			x
Anthracene	120-12-7	x			x
Benzo(a)anthracene	56-55-3	x			x
Benzo(a)pyrene	50-32-8	x			x
Benzo(b)fluoranthene	205-99-2	x			x
Benzo(g,h,i)perylene	191-24-2	x			x
Benzo(k)fluoranthene	207-08-9	x			x
Chrysene	218-01-9	x			x
Dibenzo(a,h)anthracene	53-70-3	x			x
Fluoranthene	206-44-0	x			x
Fluorene	86-73-7	x			x
Indeno(1,2,3)pyrene	193-39-5	x			x
Naphthalene	91-20-3	x			x
Phenanthrene	85-01-8	x			x
Pyrene	129-00-0	x			x
Acrolein	107-02-8	x			
Benzene	71-43-2	x			
Dioxins/Furans					
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	x			
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4	x			
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227-28-6	x			
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7	x			
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3	x			
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	x			
Octachlorodibenzo-p-dioxin	3268-87-9	x			
1,3,6,8-Tetrachlorodibenzofuran	71998-72-6	x			
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	x			
1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6	x			
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	x			
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	x			
1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9	x			
1,2,3,7,8,9-Hexachlorodibenzofuran	72918-21-9	x			
2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5	x			
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	x			
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	x			
Octachlorodibenzofuran	39001-02-0	x			
Other Parameters					
Moisture	--	x			
Solids (total)	--	x			
Total Organic Carbon	--	x			

Table 3RA-3 Representative Species Used in the Ecological Risk Assessments

Receptor	Ecological Guild	Assessment Endpoint	Exposure Media	Measurement Endpoint	Ecological Risk Assessment: Near-Field	Gap Region	San Juan River	Kayenta Mine
Terrestrial Representative Receptor								
Terrestrial Plant Community	Terrestrial vegetation	Protection and maintenance of terrestrial plant community	Soil	Comparison of soil EPC to plant benchmark	x			x
Terrestrial Invertebrate Community	Soil invertebrates	Protection and maintenance of terrestrial invertebrate community	Soil	Comparison of soil EPC to soil invertebrate benchmark	x			x
Red-tailed hawk	Terrestrial Carnivorous Birds	Protection and maintenance of terrestrial bird populations	Soil, biota, surface water	Comparison of total daily dietary uptake (dosage) to dosage-based NOAEL and LOAEL TRVs	x			x
Meadow Vole	Terrestrial Herbivorous Birds		Soil, biota, surface water		x			x
Mourning dove	Terrestrial Herbivorous Birds		Soil, biota, surface water		x			x
American robin	Terrestrial Insectivorous Birds		Soil, biota, surface water		x			x
Red fox	Terrestrial Carnivorous Mammal	Protection and maintenance of terrestrial mammal populations	Soil, biota, surface water		x			x
Little brown bat	Terrestrial Insectivorous Mammal		Biota, surface water		x			x
Dusky/Montaine shrew	Terrestrial Insectivorous Mammal		Soil, biota, surface water					x
Aquatic-Oriented Representative Receptor								
Aquatic Community	Aquatic Plants, invertebrates, fish	Protection and maintenance of aquatic community	Surface Water	Comparison of surface water EPC to water quality criteria or benchmark	x	x	x	x
Benthic Community	Sediment Invertebrates	Protection and maintenance of benthic invertebrate community	Sediment	Comparison of soil EPC to benthic invertebrate benchmark	x	x	x	x
Fish	Aquatic Carnivorous Fish	Protection and maintenance of non-special status fish community	Surface Water	Comparison of fish tissue EPC to CBR	x	x	x	x
Canvasback duck	Aquatic Herbivorous Birds		Sediment, biota, surface water	Comparison of total uptake (dosage) to dosage-based NOAEL and LOAEL TRVs	x	x	x	x
Mallard duck	Aquatic Omnivorous Birds		Sediment, biota, surface water		x	x	x	x
Muskrat	Aquatic Herbivorous Mammal		Sediment, biota, surface water		x	x	x	x
Raccoon	Aquatic Omnivorous Mammal		Sediment, biota, surface water		x	x	x	x
Little brown bat	Aquatic Insectivorous Mammal		Sediment, biota, surface water		x	x	x	x
Special Status Species								
Bluehead sucker	Aquatic Carnivorous Fish	Protection and maintenance of special status fish species	Sediment, biota, surface water	Comparison of fish tissue EPC to CBR		x	x	
Bonytail chub	Aquatic Carnivorous Fish					x		
Colorado pikeminnow	Aquatic Carnivorous Fish					x	x	
Flannelmouth sucker	Aquatic Carnivorous Fish					x		
Humback chub	Aquatic Carnivorous Fish				x	x	x	
Razorback sucker	Aquatic Carnivorous Fish					x	x	
Northern leopard frog	Aquatic Insectivorous Amphibian	Protection and maintenance of the northern leopard frog	Sediment, biota, surface water	Comparison of surface water EPC to water quality criteria and larval amphibian benchmark; and qualitative discussion of adult frogs based on surrogate fish comparison to tissue CBR	x	x		
California condor	Terrestrial Carnivorous Birds	Protection and maintenance of the California condor	Soil, biota, surface water	Comparison of total uptake (dosage) to dosage-based NOAEL and LOAEL TRVs using surrogate (red-tailed hawk); qualitative discussion	x			

Table 3RA-3 Representative Species Used in the Ecological Risk Assessments

					Ecological Risk Assessment			
Receptor	**Ecological Guild**	**Assessment Endpoint**	**Exposure Media**	**Measurement Endpoint**	**Near-Field**	**Gap Region**	**San Juan River**	**Kayenta Mine**
Mexican spotted owl	Terrestrial Carnivorous Birds	Protection and maintenance of the Mexican spotted owl	Soil, biota, surface water	Comparison of total uptake (dosage) to dosage-based NOAEL and LOAEL TRVs	x			x
Western yellow-billed cuckoo	Terrestrial Insectivorous Birds	Protection and maintenance of the western yellow-billed cuckoo	Soil, biota, surface water		x	x	x	x
Bald Eagle	Aquatic Carnivorous Birds	Protection and maintenance of the bald eagle	Biota, surface water		x	x	x	x
Southwestern willow flycatcher	Aquatic Insectivorous Birds	Protection and maintenance of the southwestern willow flycatcher	Soil, biota, surface water		x	x	x	x
Special Status Species								
Fickeisen plains cactus	Terrestrial vegetation	Protection and maintenance of the Fickeisen plains cactus	Soil	Comparison of soil EPC to plant benchmark; qualitative discussion	x			
Brady's pincushion cactus	Terrestrial vegetation	Protection and maintenance of the Brady's pincushion cactus	Soil		x			
Welsch's milkweed	Terrestrial vegetation	Protection and maintenance of the Welsch's milkweed	Soil		x			
Navajo Sedge	Aquatic-dependent vegetation	Protection and maintenance of the Navajo Sedge	Seep water (expressed groundwater)	Comparison of surface water EPC to water quality criteria or benchmark				x

Notes:

CBR = critical body residue

LOAEL = lowest observed adverse effect level

NOAEL = no observed adverse effect level

Qualitative = indicates that evaluation conducted using a weight of evidence approach considering results for surrogate species and other considerations such as life history and habitat characteristics

TRV = toxicity reference value

x = indicates receptor evaluated for given ERA

EPC = exposure point concentration. The EPCs for each medium of concern applied in the ERAs were: Maximum Scenario - maximum concentration, Refined Scenario - refined concentration represented by 95 percent upper confidence limit (if it can be calculated) and mean concentration.

Table 3RA-4 Summary of Risk to the Soil Community and Associated Wildlife in the NGS Near-Field Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	3-Unit Operation	Other Cumulative Sources (OCS)	Baseline + 3-Unit Operation + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Other Future Scenarios	Risk Conclusion
Direct Contact Exposure									
Terrestrial Plants*	Soil	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	No	No	2-Unit Operation, A1400 and OCS Residual (2045-2074) were also considered as separate scenarios: Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	risk is unlikely
Terrestrial Invertebrates	Soil	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	No	No	--	risk is unlikely
Terrestrial Wildlife - Special Status Species									
California Condor (Carnivore) Qualitative Evaluation using Red-tailed hawk surrogate	Soil, surface water, biota	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	No	No	--	risk is unlikely
Terrestrial Wildlife - Non-Special Status Species									
American Robin (invertivore)	Soil, surface water, biota	Maximum HQs<1 for all COPECs except vanadium (HQ=2). Refined HQs<1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs <1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs <1 for all COPECs.	Maximum HQs<1 for all COPECs except vanadium (HQ=2). Refined HQs<1 for all COPECs, vanadium HQ=0.7.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely
Mourning Dove (herbivore)	Soil, surface water, biota	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	No	No	--	risk is unlikely
Red-Tailed Hawk (carnivore)	Surface water, biota	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	No	No	--	risk is unlikely
Little Brown Bat (invertivore)	Surface water, biota	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	No	No	--	risk is unlikely
Meadow Vole (herbivore)	Soil, surface water, biota	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	No	No	--	risk is unlikely
Red Fox (carnivore)	Soil, surface water, biota	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	No	No	--	risk is unlikely
Dusky/Montane Shrew (invertivore)	Soil, surface water, biota	Maximum HQs≤1 for all COPECs except: HMW PAHs (HQ=2) and dioxin TEQ (HQ = 2). Refined HQs< 1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs≤1 for all COPECs except: HMW PAHs (HQ=2) and dioxin TEQ (HQ = 2). Refined HQs< 1 for all COPECs.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely

Notes:

*Evaluates the plant community as a whole. Special Status Plants with potential presence in study area include:

Fickeisen plains cactus (Pediocactus peeblesianus var. fickeiseniae)

Brady's pincushion cactus (Pediocactus bradyi)

Welsch's milkweed (Asclepias welshii)

-- = not applicable

COPEC = chemical of potential ecological concern

HMW = high molecular weight

HQ = hazard quotient

LOAEL = lowest observed adverse effect level

NOAEL - no observed adverse effect level

OCS = other cumulative sources

PAH = polycyclic aromatic hydrocarbons

TEQ = toxicity equivalency quotient

Table 3RA-5 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS Near-Field Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	3-Unit Operation	OCS	Baseline + 3-Unit Operation + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Other Future Scenarios	Risk Conclusion
Aquatic Organisms									
Aquatic Organisms (invertebrates, plants, and fish)*	Surface water	Maximum HQs≤1 for all COPECs except: total (unfiltered) aluminum (HQ=5) and selenium (HQ=3). Refined HQs≤1 for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs≤ 1 for all COPECs.	Maximum HQs≤ 1 for all COPECs. Refined HQs≤ 1 for all COPECs.	Maximum HQs≤1 for all COPECs except: total (unfiltered) aluminum (HQ=5) and selenium (HQ = 3). Refined HQs≤1 for all COPECs.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely
Benthic Organisms	Sediment	Maximum HQs≤1 for all COPECs. Refined HQs≤1 for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs≤ 1 for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs≤ 1 for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs≤ 1 for all COPECs.	No	No	--	risk is unlikely
Early Life Stage (ELS) Non-Special Status Fish**	Fish tissue	Modeled only - Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs≤ 1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs≤ 1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs≤ 1 for all COPECs.	No	No	2-Unit Operation, A1400 and OCS Residual (2045-2074) were also considered as separate scenarios: Maximum HQs ≤ 1 for all COPECs. Refined HQs ≤ 1 for all COPECs.	risk is unlikely
Adult Non-Special Status Fish**	Fish tissue	Modeled - Maximum and refined HQs< for all COPECs. Measured - Maximum and refined HQs<1 using measured mercury fish tissue concentrations.	Modeled - Maximum and refined HQs< for all COPECs. Measured - Maximum and refined HQs<1 using measured mercury fish tissue concentrations.	Modeled - Maximum and refined HQs< for all COPECs. Measured - Maximum and refined HQs<1 using measured mercury fish tissue concentrations.	Modeled - Maximum and refined HQs< for all COPECs. Measured - Maximum and refined HQs<1 using measured mercury fish tissue concentrations.	No	No	2-Unit Operation, A1400 and OCS Residual (2045-2074) were also considered as separate scenarios: Maximum modeled HQs ≤ 1 for all COPECs. Refined modeled HQs ≤ 1 for all COPECs. Maximum and refined measured fish tissue HQs were also less than 1 for all three scenarios.	risk is unlikely
Wildlife - Special Status Species									
Adult Special Status Fish	Fish tissue	Based on the draft final NGS Near-Field Ecological Risk Assessment (March 2016), adult special status fish not present in Lake Powell and were not evaluated.	--	--	--	--	--	--	--
Northern Leopard Frog Qualitative Evaluation using fish surrogate	Surface water	Evaluated qualitatively due to lack of toxicity data for amphibians. Consumes aquatic insects, exposure would be similar to fish species such as trout. Maximum and Refined HQs< 1 using measured fish tissue concentration results as a surrogate (no special status fish tissue results were available).	Modeled - Maximum and refined HQs< for all COPECs. Measured - Maximum and refined HQs<1 using measured mercury fish tissue concentrations.	Modeled - Maximum and refined HQs< for all COPECs. Measured - Maximum and refined HQs<1 using measured mercury fish tissue concentrations.	Modeled - Maximum and refined HQs< for all COPECs. Measured - Maximum and refined HQs<1 using measured mercury fish tissue concentrations.	No	No	2-Unit Operation, A1400 and OCS Residual (2045-2074) were also considered as separate scenarios: Maximum and refined measured fish tissue HQs ≤ 1 for all COPECs in the three additional scenarios. No special status fish tissue results were available.	risk is unlikely
Western Yellow-Billed Cuckoo (invertivore)	Surface water, biota	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	No	No	2-Unit Operation, A1400 and OCS Residual (2045-2074) were also considered as separate scenarios: Maximum HQs ≤ 1 for all COPECs. Refined HQs ≤ 1 for all COPECs.	risk is unlikely
Southwest Willow Flycatcher (insectivore)	Sediment, surface water, and biota	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	No	No	2-Unit Operation, A1400 and OCS Residual (2045-2074) were also considered as separate scenarios: Maximum HQs ≤ 1 for all COPECs. Refined HQs ≤ 1 for all COPECs.	risk is unlikely

Table 3RA-5 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS Near-Field Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	3-Unit Operation	OCS	Baseline + 3-Unit Operation + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Other Future Scenarios	Risk Conclusion
Wildlife - Non-Special Status									
Bald Eagle (carnivore)	Surface water, biota	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	No	No	--	risk is unlikely
Canvasback Duck (herbivore)	Sediment, surface water, and biota	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	No	No	--	risk is unlikely
Mallard Duck (omnivore)	Sediment, surface water, and biota	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	No	No	--	risk is unlikely
Muskrat (herbivore)	Sediment, surface water, biota	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	No	No	--	risk is unlikely
Raccoon (omnivore)	Sediment, surface water, biota	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	No	No	--	risk is unlikely

Notes:

*For evaluation of the aquatic community use of the dissolved (filtered) water concentration is generally of most relevance for most metals including arsenic and mercury/methylmercury, as it represents the bioavailable fraction of COPECs. The exceptions are aluminum and selenium that are typically evaluated using total (unfiltered) concentrations.

**Modeled fish tissue concentrations were developed using a site-specific bioaccumulation factor and surface water concentrations. Measured fish tissue concentrations were not available for ELS fish; measured tissue concentrations were available for adult fish only.

-- = not applicable

CBR = critical body residues

COPEC = chemical of potential ecological concern

EPC = exposure point concentration

HQ = hazard quotient

LOAEL = lowest observed adverse effect level

NOAEL - no observed adverse effect level

OCS = other cumulative sources

UCL = upper confidence limit

Table 3RA-6 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS Northeast Gap Region Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	3-Unit Operation	OCS	Baseline + 3-Unit Operation + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Comments on Other Scenarios	Risk Conclusion
Aquatic and Benthic Community									
Aquatic Organisms*	Surface water	Dissolved Basis - Maximum HQs<1 for all COPECs except selenium (HQ=2). Refined HQs<1 for all COPECs. Total (unfiltered) basis - Maximum HQs < 1 for all COPECs except selenium (HQ=3). Refined HQs ≤ 1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Dissolved Basis - Maximum HQs<1 for all COPECs Refined HQs<1 for all COPECs. Total (unfiltered) basis - Maximum HQs<1 for all COPECs except mercury (HQ=2) and methyl mercury (HQ=2). Refined HQs<1 for all COPECs.	Dissolved Basis - Maximum HQs<1 for all COPECs except selenium (HQ=2) Refined HQs<1 for all COPECs. Total (unfiltered) basis - Maximum HQs < 1 for all COPECs except mercury (HQ2), methyl mercury (HQ=2) and selenium (HQ=3). Refined HQs ≤ 1 for all COPECs.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs < 1 for all COPECs unless baseline and/or OCS is also included.	risk is unlikely
Benthic Macroinvertebrates	Sediment	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	No	No	--	risk is unlikely
Early Life Stage (ELS) Non-Special Status Fish**	Surface water	Modeled only - Maximum HQs< for all COPECs except mercury (HQ=4). Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Modeled only - Maximum HQs≤ 1 for all COPECs except mercury (HQ=4). Refined HQ<1 for all COPECs.	Yes	No	Except for mercury (maximum HQ = 4) due to baseline, maximum and refined HQs < 1 for all COPECs when evaluating the 2-Unit Operation, A1400 or OCS (2045-2074) contributions.	risk is unlikely
Adult Non-Special Status Fish**	Surface water	Modeled - Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs. Measured - Maximum HQs<1 for all measured mercury in all species of fish. Refined HQs<1 for measured mercury in all species of fish.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Modeled - Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs. Measured - Maximum HQs<1 for all measured mercury in all species of fish. Refined HQs<1 for measured mercury in all species of fish.	No	No	When evaluating other scenarios (2-Unit Operation, A1400, OCS 2045-2074), maximum and refined HQs < 1 for all COPECs using modeled or measured fish tissue concentrations. The only exception is when using measured mercury fish tissue concentrations in the OCS 2045-2074 + 3-Unit Operation scenario, HQ = 2 for the striped bass.	risk is unlikely
Special Status Species									
Adult Special Status Fish (humpback chub, roundtail chub, bonytail chub, razorback sucker and Colorado pikeminnow)	Surface water	Measured only - Maximum HQs<1 for all special status species. Refined HQs<1 for all special status species.	Maximum HQs<1 for all special status species. Refined HQs<1 for all special status species.	Maximum HQs=1 for all special status species. Refined HQs<1 for all special status species.	The OCS contribution had an effect on the combined risk for mercury- Maximum HQs =2 for all five species. Refined HQs =1 for all five species.	Yes	No	In the 2-Unit Operation and A1400 scenarios, the OCS contribution had an effect on the combined risk for mercury for all five special status species (HQs=2). In the refined evaluation HQs=1 for all five special status species. In contrast, the OCS 2045-2074 scenario resulted in maximum HQs=3 and refined HQs=2 for all five species.	risk is unlikely
Northern Leopard Frog (Qualitative Evaluation)	Surface water	Evaluated qualitatively due to lack of toxicity data available for amphibians. Consumes aquatic insects, exposure would be similar to fish species such as trout. Given that HQs were < 1 for all special status fish species in the maximum and refined screens, potential risk to the northern leopard frog is not expected.	Based on special status fish, maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs. Potential risk to the northern leopard frog is not expected.	Based on special status fish, maximum HQs = 1 for all COPECs and refined HQs < 1 for all COPECs. Potential risk from exposure to mercury cannot be ruled out for the Northern Leopard Frog.	As stated above, the OCS contribution had an effect on the combined risk for mercury for all five special status species of fish particularly when assuming maximum exposures. Potential risk from exposure to mercury cannot be ruled out for the Northern Leopard Frog.	Yes	No	The qualitative evaluation is based on special status fish species results. In the 2-Unit Operation and A1400 scenarios, the OCS contribution had an effect on the combined risk for mercury for all five special status species (HQs=2). In the refined evaluation HQs=1 for all five special status species. In contrast, the OCS 2045-2074 scenario resulted in maximum HQs=3 and refined HQs=2 for all five species.	risk is unlikely
Western Yellow-billed Cuckoo (insectivore)	Surface water, and biota	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs < 1 for all COPECs.	risk is unlikely
Southwestern Willow Flycatcher (insectivore)	Surface water, and biota	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs < 1 for all COPECs.	risk is unlikely

Table 3RA-6 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS Northeast Gap Region Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	3-Unit Operation	OCS	Baseline + 3-Unit Operation + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Comments on Other Scenarios	Risk Conclusion
Wildlife - Non-Special Status Species									
Bald Eagle (carnivore)	Sediment, surface water, biota	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	Except for methyl mercury (HQ=2 due to a combination of contributions from baseline and OCS), maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely
Canvasback Duck (herbivore)	Surface water, and biota	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	--	risk is unlikely
Mallard Duck (omnivore)	Surface water, and biota	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	--	risk is unlikely
Muskrat (herbivore)	Sediment, surface water, biota	Maximum HQs < 1 for all COPECs except arsenic (HQ=2), mercury (HQ=2) and selenium (HQ=2). Refined HQs < 1 for all COPECs	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs except arsenic (HQ=2), mercury (HQ=2) and selenium (HQ=2) due to baseline contributions. Refined HQs < 1 for all COPECs	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely
Raccoon (omnivore)	Sediment, surface water, biota	Maximum HQs < 1 for all COPECs except selenium (HQ=2). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs except selenium (HQ=2) due to baseline concentrations. Refined HQs < 1 for all COPECs.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely
Little Brown Bat (insectivore)	Surface water, and biota	Maximum HQs < 1 for all COPECs except selenium (HQ=2). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs except selenium (HQ=2) due to baseline concentrations. Refined HQs < 1 for all COPECs.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely

Table 3RA-7 Summary of Risk to the Aquatic and Benthic Community and Wildlife in the NGS Southwest Gap Region Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	3-Unit Operation	OCS	Baseline + 3-Unit Operation + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Comments on Other Scenarios	Risk Conclusion
Aquatic and Benthic Community									
Aquatic Organisms	Surface water	Dissolved Basis - Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs. Total (unfiltered) basis - Maximum HQs < 1 for all COPECs except selenium (HQ=6). Refined HQs ≤ 1 for all COPECs except selenium (HQ=6).	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Dissolved Basis - Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs. Total (unfiltered) basis - Maximum HQs < 1 for all COPECs except selenium (HQ=6) due to the baseline contribution. Refined HQs ≤ 1 for all COPECs except selenium (HQ=6) due to the baseline contribution.	Yes	Yes	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk cannot be ruled out
Benthic Macroinvertebrates	Sediment	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	--	risk is unlikely
Early Life Stage (ELS) Non-Special Status Fish	Surface water	Modeled only - Maximum HQs ≤ 1 for all COPECs. Refined HQ ≤ 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs. Refined HQs ≤ 1 for all COPECs.	No	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs ≤ 1 for all COPECs.	risk is unlikely
Adult Non-Special Status Fish	Surface water	Modeled only - Maximum HQs ≤ 1 for all COPECs. Refined HQs ≤ 1 for all COPECs. Measured only - Maximum mercury HQs > 1 for the fathead minnow (HQ = 2), rainbow trout (HQ = 3) and speckled dace (HQ = 3). Maximum selenium HQs > 1 for the common carp (HQ = 2), rainbow trout (HQ = 4) and the speckled dace (HQ = 2). Refined mercury HQs were > 1 for the fathead minnow (HQ = 2), rainbow trout (HQ = 2) and speckled dace (HQ = 2). Refined selenium HQs > 1 for the rainbow trout (HQ = 2) and the speckled dace (HQ = 2).	Modeled Only - Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs. Measured Only - Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Modeled Only - Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs. Measured Only - Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Modeled only - Maximum HQs ≤ 1 for all COPECs. Refined HQs ≤ 1 for all COPECs. Measured only - Maximum mercury HQs > 1 for the fathead minnow (HQ = 3), flannelmouth sucker (HQ=2), rainbow trout (HQ = 4) and speckled dace (HQ = 4). Maximum selenium HQs > 1 for the common carp (HQ = 2), rainbow trout (HQ = 4) and the speckled dace (HQ = 2). Refined mercury HQs were > 1 for the fathead minnow (HQ = 2), rainbow trout (HQ = 2) and speckled dace (HQ = 2). Refined selenium HQs > 1 for the rainbow trout (HQ = 2) and the speckled dace (HQ = 2).	Yes	Yes	Maximum and refined HQs ≤ 1 for all COPECs when evaluating just the 2-Unit Operation or A1400 contributions. When adding baseline + OCS, results are similar to baseline + OCS + 3-Unit Operation. Baseline + 3-Unit Operation + OCS (2045-2074) resulted in marked increases in HQs: Using modeled fish tissue concentrations, methyl mercury (maximum HQ=2, refined HQ=2). Using measured mercury fish tissue concentrations, maximum HQs = 2 for all species of fish except fathead minnow (HQ=4), flannelmouth sucker (HQ=3), rainbow trout (HQ=5), and speckled dace (HQ=5). Refined HQs were > 1 for the fathead minnow (HQ=3), flannelmouth sucker (HQ=2), rainbow trout (HQ=3), and speckled dace (HQ=3). Using measured selenium fish tissue concentrations, maximum HQs > 1 for the common carp (HQ=2), rainbow trout (HQ=4) and speckled dace (HQ=2). Refined HQs > 1 for the rainbow trout (HQ=2) and speckled dace (HQ=2).	risk cannot be ruled out

Table 3RA-7 Summary of Risk to the Aquatic and Benthic Community and Wildlife in the NGS Southwest Gap Region Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	3-Unit Operation	OCS	Baseline + 3-Unit Operation + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Comments on Other Scenarios	Risk Conclusion
Special Status Species									
Adult Special Status Fish (humpback chub, roundtail chub, bonytail chub and razorback sucker)	Surface water	Measured only - Maximum mercury HQs ≤ 1 for all species except the razorback sucker, using flannelmouth sucker data (HQ=5). Maximum selenium HQs ≤ 1 for all four species. Refined mercury HQs ≤ 1 for all species except the razorback sucker, using flannelmouth sucker data (HQ=3). Refined selenium HQs ≤ 1 for all four species.	Maximum mercury and selenium HQs < 1 for all four species. Refined mercury and selenium HQs < 1 for all four species.	Maximum mercury HQs = 4 for all four species. Maximum selenium HQs < 1 for all four species. Refined mercury HQs = 2 for all four species. Refined selenium HQs < 1 for all four species.	Maximum mercury HQs > 1 for the humpback chub (HQ = 4), roundtail chub (HQ=4), bonytail chub (HQ = 4) and razorback sucker (HQ = 8). Maximum selenium HQs ≤ 1 for all four species. Refined mercury HQs > 1 for the humpback chub (HQ = 3), roundtail chub (HQ=3), bonytail chub (HQ = 3) and razorback sucker (HQ = 5). Refined selenium HQs ≤ 1 for all four species.	Yes	Yes	Maximum and refined HQs ≤ 1 for all COPECs when evaluating just the 2-Unit Operation or A1400 contribution. However, similar to 3-Unit Operation HQ results when adding baseline + OCS. When adding the 3-Unit Operation + OCS (2045-2074) to baseline, maximum mercury HQs were > 1 for all four special status species: humpback chub (HQ=8), roundtail chub (HQ=8), bonytail chub (HQ=8) and razorback sucker (HQ=10 based on flannelmouth sucker data and HQ=9 based on bluehead sucker data). Refined mercury HQs were > 1 for the humpback chub (HQ=5), roundtail chub (HQ=5), bonytail chub (HQ=5) and razorback sucker (HQ=8 based on flannelmouth sucker data and HQ=5 based on bluehead sucker data).	risk cannot be ruled out
Northern Leopard Frog (Qualitative Evaluation)	Surface water	Using special status fish tissue results as a surrogate - Maximum mercury HQs ≤ 1 for all species except the razorback sucker, using flannelmouth sucker data (HQ=5). Maximum selenium HQs ≤ 1 for all four species. Refined mercury HQs ≤ 1 for all species except the razorback sucker, using flannelmouth sucker data (HQ=3). Refined selenium HQs ≤ 1 for all four species.	Based on special status fish, maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs. Potential risk to the northern leopard frog is not expected.	Using special status species of fish results - Maximum mercury HQs = 4 for all four species. Maximum selenium HQs < 1 for all four species. Refined mercury HQs = 2 for all four species. Refined selenium HQs < 1 for all four species. Potential risk from exposure to mercury cannot be ruled out for the Northern Leopard Frog.	As stated above for special status species of fish, the combined contribution from baseline and OCS had an effect on the cumulative risk from exposure to mercury for all four special status species of fish. Therefore, risk from the combined cumulative exposure to mercury cannot be ruled out for the Northern Leopard Frog.	Yes	Yes	As stated above, the individual contribution from 2-Unit Operation or A1400 resulted in HQs < 1. However, the combined contribution from baseline and OCS had an effect on the cumulative risk from exposure to mercury for all four special status species of fish. Therefore, risk from the combined cumulative exposure to mercury cannot be ruled out for the Northern Leopard Frog.	risk cannot be ruled out
Western Yellow-billed Cuckoo (insectivore)	Surface water, and biota	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL- and LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL- and LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL- and LOAEL-based HQs < 1 for all COPECs.	No	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs < 1 for all COPECs.	risk is unlikely
Southwestern Willow Flycatcher (insectivore)	Surface water, and biota	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL- and LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL- and LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL- and LOAEL-based HQs < 1 for all COPECs.	No	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs < 1 for all COPECs.	risk is unlikely
Wildlife - Non-Special Status Species									
Bald Eagle (carnivore)	Sediment, surface water, biota	Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 4). Refined NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 3). Refined LOAEL HQs < 1.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 3). Refined NOAEL-based HQs < 1 for all COPECs except methyl mercury (HQ =2). Refined LOAEL-based HQs < 1.	Adding the OCS contribution to baseline resulted in the following - Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ =7). Refined NOAEL-based HQs < 1 for all COPECs except methyl mercury (HQ = 5). Refined LOAEL-based HQs < 1.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely (LOAEL-based HQs < 1)
Canvasback Duck (herbivore)	Surface water, and biota	Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 4). Refined NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 3). Refined LOAEL HQs < 1.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	HQs >1 primarily result of baseline contribution - Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 4). Refined NOAEL-based HQs < 1 for all COPECs except methyl mercury (HQ = 3). Refined LOAEL-based HQs < 1.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely (LOAEL-based HQs < 1)

Table 3RA-7 Summary of Risk to the Aquatic and Benthic Community and Wildlife in the NGS Southwest Gap Region Study Area

Assessment		Maximum and Refined Risk Estimates							
Endpoint	**Exposure Medium**	**Baseline**	**3-Unit Operation**	**OCS**	**Baseline + 3-Unit Operation + OCS**	**Are Maximum HQs > 1?**	**Are Refined HQs > 1?**	**Comments on Other Scenarios**	**Risk Conclusion**
Mallard Duck (omnivore)	Surface water, and biota	Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 4). Refined NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 3). Refined LOAEL HQs < 1.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	HQs >1 primarily result of baseline contribution - Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 4). Refined NOAEL-based HQs < 1 for all COPECs except methyl mercury (HQ = 3). Refined LOAEL-based HQs < 1.	Yes	No	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely (LOAEL-based HQs < 1)
Muskrat (herbivore)	Sediment, surface water, biota	Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 3) and selenium (HQ=3). Refined NOAEL HQs were < 1 for all COPECs except methyl mercury (HQ = 2) and selenium (HQ=2). Refined LOAEL HQs < 1 except selenium (HQ=2).	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	HQs > 1 primarily result of baseline - Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 3) and selenium (HQ=3). Refined NOAEL-based HQs were < 1 for all COPECs except methyl mercury (HQ = 2) and selenium (HQ=2). Refined LOAEL-based HQs < 1 except selenium (HQ=2).	Yes	Yes	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk cannot be ruled out
Raccoon (omnivore)	Sediment, surface water, biota	Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 2) and selenium (HQ=3). Refined NOAEL HQs were < 1 for all COPECs except methyl mercury (HQ = 2) and selenium (HQ=2). Refined LOAEL HQs < 1 except selenium (HQ=2).	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	HQs > 1 primarily result of baseline contribution - Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 2) and selenium (HQ=3). Refined NOAEL-based HQs were < 1 for all COPECs except methyl mercury (HQ = 2) and selenium (HQ=2). Refined LOAEL-based HQs < 1 except selenium (HQ=2).	Yes	Yes	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk cannot be ruled out
Little Brown Bat (insectivore)	Surface water, and biota	Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 2) and selenium (HQ=3). Refined NOAEL HQs were < 1 for all COPECs except selenium (HQ=2). Refined LOAEL HQs < 1 except selenium (HQ=2).	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	Maximum NOAEL- based HQs < 1 for all COPECs. Refined NOAEL-based HQs < 1 for all COPECs. Refined LOAEL-based HQs < 1 for all COPECs.	HQs > 1 primarily the result of baseline contribution - Maximum NOAEL HQs < 1 for all COPECs except methyl mercury (HQ = 2) and selenium (HQ=3). Refined NOAEL-based HQs were < 1 for all COPECs except selenium (HQ=2). Refined LOAEL-based HQs < 1 except selenium (HQ=2).	Yes	Yes	Other scenarios (2-Unit Operation, A1400, OCS 2045-2074) were not evaluated for this receptor.	risk cannot be ruled out

Notes:

CBR = critical body residues
COPEC = chemical of potential ecological concern
ELS = early life stage
EPC = exposure point concentration
HQ = hazard quotient
LOAEL = lowest observed adverse effect level
NOAEL - no observed adverse effect level
OCS = other cumulative sources
UCL = upper confidence limit

Table 3RA-8 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS San Juan River Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates				Are Maximum HQs > 1?	Are Refined HQs > 1?	Comments on Other Scenarios	Risk Conclusion
		Baseline	3-Unit Operation	OCS	Baseline + 3-Unit Operation + OCS				
Aquatic and Benthic Community									
Aquatic Organisms*	Surface water	Dissolved Basis - Maximum HQs<1 for all COPECs except mercury (HQ=2); selenium (HQ=4) based on total (unfiltered) results Refined HQs<1 for all COPECs. Total (unfiltered) basis - Maximum HQs<1 for all COPECs except selenium (HQ=3); mercury (HQ=50) based on dissolved (filtered) result. Refined HQs<1 for all COPECs; mercury (HQ=4) based on dissolved (filtered) result.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Dissolved Basis - Maximum HQs<1 for all COPECs except mercury (HQ=2); selenium (HQ=4) based on total (unfiltered) results Refined HQs<1 for all COPECs. Total (unfiltered) basis - Maximum HQs<1 for all COPECs except selenium (HQ=3); mercury (HQ=50) based on dissolved (filtered) result. Refined HQs<1 for all COPECs; mercury (HQ=4) based on dissolved (filtered) result.	Yes	No	Other scenarios (2-Unit Operation and OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs ≤ 1 for all COPECs when considering these individual contributions.	risk is unlikely
Benthic Macroinvertebrates	Sediment	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Future concentrations not estimated	Future concentrations not estimated	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	No	No	--	risk is unlikely
Early Life Stage (ELS) Non-Special Status Fish**	Surface water	Modeled only - Maximum HQs< for all COPECs except arsenic (HQ=5). Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Modeled only - Maximum HQs< for all COPECs except arsenic (HQ=5). Refined HQ<1 for all COPECs.	Yes	No	--	risk is unlikely
Adult Non-Special Status Fish**	Surface water	Modeled - Maximum HQs<1 for all COPECs except mercury (HQ = 7). Refined HQs≤1 for all COPECs. Measured - Maximum HQs≤1 for all COPECs except selenium (HQ=2, speckled dace). Fish average HQ<1 for all COPECs. Refined HQs≤1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Modeled - Maximum HQs<1 for all COPECs except mercury (HQ = 7). Refined HQs≤1 for all COPECs. Measured - Maximum HQs≤1 for all COPECs except selenium (HQ=2, speckled dace). Fish average HQ<1 for all COPECs. Refined HQs≤1 for all COPECs.	Yes	No	Other scenarios (2-Unit Operation and OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs ≤ 1 for all COPECs when considering these individual contributions.	risk is unlikely
Special Status Species									
Adult Special Status Fish (Colorado pikeminnow, roundtail chub and razorback sucker)	Surface water	Measured only - Maximum HQs≤1 for all COPECs; mercury (HQ=1, pikeminnow), selenium (HQ=1, razorback). Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Measured only - Maximum HQ<1 for arsenic; mercury (HQ=2, pikeminnow) and selenium (HQ=1, razorback). The OCS contribution was about 33% of total cumulative exposure HQ for mercury. Refined HQs<1 for arsenic and selenium; mercury (HQ=1, pikeminnow) Based on baseline measured surrogate species data (striped bass) for pikeminnow, total cumulative risk is indicated from mercury (maximum HQ=3, refined HQ=2). For razorback sucker, baseline tissue selenium refined HQ<1 (maximum HQ=1, refined HQ<1).	Yes	No***	Other scenarios (2-Unit Operation and OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs ≤ 1 for all COPECs when considering these individual contributions.	risk is unlikely
Northern Leopard Frog Qualitative Evaluation using fish surrogate	Surface water	Evaluated qualitatively due to lack of toxicity data available for amphibians. Consumes aquatic insects, exposure would be similar to fish species such as trout. Given that maximum and refined HQs≤1 for all three special status species of fish, potential risk to the northern leopard frog is not expected.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs. Potential risk to the northern leopard frog is not expected.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs. Potential risk to the northern leopard frog is not expected.	As stated above, the OCS contribution increased the risk for mercury (maximum HQ = 2) for the Colorado pikeminnow which may result in a potential concern for the northern leopard frog. Refined HQ=1 for pikeminnow.	Yes	No	Other scenarios (2-Unit Operation and OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs<1 for all COPECs when considering these individual contributions.	risk is unlikely
Western Yellow-billed Cuckoo (insectivore)	Surface water, and biota	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	No	No	Other scenarios (2-Unit Operation and OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs<1 for all COPECs.	risk is unlikely
Southwestern Willow Flycatcher (insectivore)	Surface water, and biota	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	No	No	Other scenarios (2-Unit Operation and OCS 2045-2074) were evaluated for this receptor. Maximum and refined HQs<1 for all COPECs.	risk is unlikely
Wildlife - Non-Special Status Species									
Bald Eagle (carnivore)	Sediment, surface water, biota	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	No	No	--	risk is unlikely
Canvasback Duck (herbivore)	Surface water, and biota	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	No	No	--	risk is unlikely
Mallard Duck (omnivore)	Surface water, and biota	Maximum HQs≤ 1 for all COPECs except methyl mercury (HQ=2) and selenium (HQ=2). Refined HQs<1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs≤1 for all COPECs except methyl mercury (HQ=3) and selenium (HQ=2). Refined HQs≤1 for all COPECs. Reported risk estimate is mostly due to baseline.	Yes	No	Other scenarios (2-Unit Operation and OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely

Table 3RA-8 Summary of Risk to the Aquatic and Benthic Community and Associated Wildlife in the NGS San Juan River Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	3-Unit Operation	OCS	Baseline + 3-Unit Operation + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Comments on Other Scenarios	Risk Conclusion
Muskrat (herbivore)	Sediment, surface water, biota	Maximum HQs≤1 for all COPECs except selenium (HQ=2). Refined HQs<1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs≤1 for all COPECs except selenium (HQ=2). Refined HQs<1 for all COPECs. Reported risk estimate is mostly due to baseline.	Yes	No	Other scenarios (2-Unit Operation and OCS 2045-2074) were not evaluated for this receptor.	risk is unlikely
Raccoon (omnivore)	Sediment, surface water, biota	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	No	No	--	risk is unlikely
Little Brown Bat (insectivore)	Surface water, and biota	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs< for all COPECs. Refined HQs< for all COPECs.	Maximum HQs≤1 for all COPECs. Refined HQs<1 for all COPECs.	No	No	--	risk unlikely

Notes:

*For evaluation of the aquatic community use of the dissolved (filtered) water concentration is generally of most relevance for most metals including arsenic and mercury/methylmercury, as it represents the bioavailable fraction of COPECs. The exception is selenium that is typically evaluated using total (unfiltered) concentrations. Dissolved results for selenium and total results for mercury are presented for reference only.

**Modeled fish tissue concentrations were developed using a site-specific bioaccumulation factor and surface water concentrations. Measured fish tissue concentrations were not available for ELS fish; measured tissue concentrations were available for adult fish only.

***For the Colorado pikeminnow, potential risk is possible based consideration of surrogate fish tissue data results. Because the measured tissue data were obtained from stock fish, there is some uncertainty in the results as it is possible that tissue concentrations of stocked fish may not be in equilibrium with the San Juan River ecosystem and therefore may underestimate exposure to pikeminnow relative to native/resident fish. The level of underestimation however is likely to be low.

CBR = critical body residues
COPEC = chemical of potential ecological concern
CPM = Colorado pikeminnow
ELS = early life stage
EPC = exposure point concentration
HQ = hazard quotient
LOAEL = lowest observed adverse effect level
NOAEL - no observed adverse effect level
OCS = other cumulative sources
UCL = upper confidence limit

Table 3RA-9 Summary of Risk to the Soil Community, Aquatic and Benthic Community and Associated Wildlife in the Kayenta Mine Complex Study Area

Assessment		Maximum and Refined Risk Estimates							
Endpoint	**Exposure Medium**	**Baseline**	**8.1 MTPY**	**OCS**	**Baseline + 8.1 MTPY + OCS**	**Are Maximum HQs > 1?**	**Are Refined HQs > 1?**	**Comments on Other Scenarios**	**Risk Conclusion**
Terrestrial Communities									
Terrestrial Plants*	Soil	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Terrestrial Invertebrates	Soil	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Terrestrial Wildlife									
American Robin	Soil, biota (terrestrial), surface water	Maximum HQs ≤ 1 for all COPECs except vanadium (HQ = 2). Refined HQs ≤ 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs except vanadium (HQ = 2) and methyl mercury (HQ=2). Refined HQs ≤ 1 for all COPECs.	Yes	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Mourning Dove	Soil, biota (terrestrial), surface water	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Red-tailed Hawk	Biota (terrestrial), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Little Brown Bat	Biota (aquatic and terrestrial), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Meadow Vole	Soil, biota (terrestrial), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Red Fox	Soil, biota (terrestrial), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Dusky/Montane Shrew	Soil, biota (terrestrial), surface water	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Terrestrial and Aquatic Wildlife - Special Status Species									
Mexican Spotted Owl	Biota (terrestrial), surface water	Maximum HQs < 1 for all COPECs except methyl mercury (HQ=1). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs except methyl mercury (HQ=1). Refined HQs < 1 for all COPECs.	Yes	No	An alternative scenario (5.5 MTPY) was evaluated for this receptor. Maximum HQs < 1 for all COPECs except methyl mercury (HQ=1). Refined HQs < 1 for all COPECs.	risk is unlikely
Western Yellow-billed Cuckoo	Biota (aquatic, terrestrial), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	An alternative scenario (5.5 MTPY) was evaluated for this receptor. Maximum and refined HQs < 1 for all COPECs.	risk is unlikely
Southwestern Willow Flycatcher	Sediment, biota (aquatic), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	An alternative scenario (5.5 MTPY) was evaluated for this receptor. Maximum and refined HQs < 1 for all COPECs.	risk is unlikely

Table 3RA-9 Summary of Risk to the Soil Community, Aquatic and Benthic Community and Associated Wildlife in the Kayenta Mine Complex Study Area

Assessment		Maximum and Refined Risk Estimates							
Endpoint	Exposure Medium	Baseline	8.1 MTPY	OCS	Baseline + 8.1 MTPY + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Comments on Other Scenarios	Risk Conclusion
Aquatic Wildlife									
Bald Eagle	Biota (fish), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs except methyl mercury (HQ=2). Refined HQs < 1 for all COPECs except methyl mercury (HQ=2).	Maximum NOAEL-based HQs < 1 for all COPECs except methyl mercury (HQ=3). Refined NOAEL-based HQs < 1 for all COPECs except methyl mercury (HQ=2). Refined LOAEL-based HQs < 1 for all COPECs.	Yes	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Canvasback Duck	Sediment, biota (aquatic), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Mallard Duck	Sediment, biota (aquatic), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Muskrat	Sediment, biota (aquatic), surface water	Maximum HQs ≤ 1 for all COPECs except cadmium (HQ = 2). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs except cadmium (HQ = 2). Refined HQs < 1 for all COPECs.	Yes	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Raccoon	Sediment, biota (aquatic), surface water	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	No	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS.	risk is unlikely
Aquatic and Benthic Community									
Aquatic Organisms - Ponds**	Surface water - Total Metals	Maximum HQs >1 include: aluminum (HQ = 400), cadmium (HQ = 2), copper (HQ = 2), iron (HQ=30), lead (HQ = 3), mercury (HQ = 30), selenium (HQ = 5), and vanadium (HQ = 5). Refined HQs >1 include: aluminum (HQ = 200), iron (HQ=7), lead (HQ = 2), mercury (HQ = 4), selenium (HQ = 3), and vanadium (HQ = 3).	Maximum HQs ≤ 1 for all COPECs except iron (HQ=3). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs >1 include: aluminum (HQ = 400), cadmium (HQ = 2), copper (HQ = 2), iron (HQ=33), lead (HQ = 3), mercury (HQ = 30), selenium (HQ = 5), and vanadium (HQ = 5). Refined HQs >1 include: aluminum (HQ = 200), iron (HQ=7), lead (HQ = 2), mercury (HQ = 4), selenium (HQ = 3), and vanadium (HQ = 3).	Yes	Yes	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS except maximum for iron.	Risk not expected - aquatic communities tolerant of local hydrogeologic conditions
	Surface water - Dissolved Metals	Maximum HQs > 1 include: aluminum (HQ= 9), cadmium (HQ = 10), manganese (HQ = 20) and zinc (HQ = 2). Refined HQs > 1 include: aluminum (HQ = 4), cadmium (HQ = 2),and manganese (HQ = 4).	Maximum HQs ≤ 1 for all COPECs except iron (HQ=3). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs > 1 include: aluminum (HQ= 9), cadmium (HQ = 10), iron (HQ=3), manganese (HQ = 20) and zinc (HQ = 2). Refined HQs > 1 include: aluminum (HQ = 4), cadmium (HQ = 2),and manganese (HQ = 4).	Yes	Yes	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS except maximum for iron.	Risk not expected - aquatic communities tolerant of local hydrogeologic conditions
Aquatic Organisms - Base Flow (Washes)**	Surface water - Total Metals	Maximum HQs > 1 include: aluminum (HQ = 4) and selenium (HQ = 2). Refined HQs > 1 include: aluminum (HQ = 2).	Maximum HQs ≤ for all COPECs except iron (HQ=3). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs > 1 include: aluminum (HQ = 4), iron (HQ=3) and selenium (HQ = 2). Refined HQs > 1 include: aluminum (HQ = 2).	Yes	Yes	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS except maximum for iron.	Risk not expected - aquatic communities limited or absent due to small extent/variable flow regime and/or tolerance to local hydrogeologic conditions
	Surface water - Dissolved Metals	Maximum HQs > 1 include: manganese (maximum HQ = 20) and vanadium (maximum HQ = 3). Refined HQs > 1 include: manganese (refined HQ = 5).	Maximum HQs ≤ 1 for all COPECs except iron (HQ=3). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs > 1 include: iron (HQ=3), manganese (maximum HQ = 20) and vanadium (maximum HQ = 3). Refined HQs > 1 include: manganese (refined HQ = 5).	Yes	Yes	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS except maximum for iron.	Risk not expected - aquatic communities limited or absent due to small extent/variable flow regime and/or tolerance to local hydrogeologic conditions
Aquatic Organisms - Springs**	Surface water - Total Metals	Maximum HQs > 1 include: aluminum (HQ = 30), cadmium (HQ = 5), iron (HQ = 3), manganese (HQ = 3), selenium (HQ = 90), vanadium (HQ = 3) and zinc (HQ = 3). Refined HQs > 1 include: aluminum (HQ = 10), cadmium (HQ = 2) and selenium (HQ = 40).	Maximum HQs ≤ 1 for all COPECs except iron (HQ=3). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs > 1 include: aluminum (HQ = 30), cadmium (HQ = 5), iron (HQ = 6), manganese (HQ = 3), selenium (HQ = 90), vanadium (HQ = 3) and zinc (HQ = 3). Refined HQs > 1 include: aluminum (HQ = 10), cadmium (HQ = 2) and selenium (HQ = 40).	Yes	Yes	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS except maximum for iron.	Risk not expected - aquatic communities limited or absent due to small extent/variable flow regime and/or tolerance to local hydrogeologic conditions
	Surface water - Dissolved Metals	Maximum HQs > 1 include: aluminum (HQ = 3), boron (HQ = 2), cadmium (HQ = 7), manganese (HQ = 40), selenium (HQ = 40), vanadium (HQ = 2) and zinc (HQ = 3). Refined HQs > 1 include: cadmium (HQ = 2), manganese (HQ = 20) and selenium (HQ = 30).	Maximum HQs ≤ 1 for all COPECs except iron (HQ=3). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs > 1 include: aluminum (HQ = 3), boron (HQ = 2), cadmium (HQ = 7), iron (HQ=3), manganese (HQ = 40), selenium (HQ = 40), vanadium (HQ = 2) and zinc (HQ = 3). Refined HQs > 1 include: cadmium (HQ = 2), manganese (HQ = 20) and selenium (HQ = 30).	Yes	Yes	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS except maximum for iron.	Risk not expected - aquatic communities limited or absent due to small extent/variable flow regime and/or tolerance to local hydrogeologic conditions
Benthic Macroinvertebrates	Sediment	Maximum HQs ≤ 1 for all COPECs except zinc (HQ=2). Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs < 1 for all COPECs. Refined HQs < 1 for all COPECs.	Maximum HQs ≤ 1 for all COPECs except zinc (HQ=2) due to the baseline contribution. Refined HQs < 1 for all COPECs.	Yes	No	5.5 MTPY scenario maximum and refined HQs<1 for all COPECS except maximum for iron.	risk is unlikely

Table 3RA-9 Summary of Risk to the Soil Community, Aquatic and Benthic Community and Associated Wildlife in the Kayenta Mine Complex Study Area

Assessment Endpoint	Exposure Medium	Maximum and Refined Risk Estimates: Baseline	8.1 MTPY	OCS	Baseline + 8.1 MTPY + OCS	Are Maximum HQs > 1?	Are Refined HQs > 1?	Comments on Other Scenarios	Risk Conclusion
Early Life Stage (ELS) Non-Special Status Fish***	Surface water	Modeled only - Maximum HQs< for all COPECs. Refined HQ<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Modeled - Maximum HQs ≤ 1 for all COPECs. Reported risk estimate for arsenic (HQ=1) mostly due to baseline, with contribution (20%) from 8.1 MTPY operation. Refined HQs<1 for all COPECs.	No	No	5.5 MTPY scenario indicated maximum and refined HQ<1.	risk is unlikely
Adult Non-Special Status Fish***	Surface water	Modeled - Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Maximum HQs<1 for all COPECs. Refined HQs<1 for all COPECs.	Modeled - Maximum HQs < 1 for all COPECs. Refined HQs<1 for all COPECs.	No	No	5.5 MTPY scenario indicated maximum and refined HQ<1.	risk is unlikely

Notes:

*Evaluates the plant community as a whole. Special Status Plants with potential presence in study area includes the Navajo Sedge.

**For evaluation of the aquatic community use of the dissolved (filtered) water concentration is generally of most relevance for most metals including arsenic and mercury/methylmercury, as it represents the bioavailable fraction of COPECs. The exception is selenium that is typically evaluated using total (unfiltered) concentrations. Dissolved results for selenium and total results for mercury are presented for reference only.

***Modeled fish tissue concentrations were developed using a site-specific bioaccumulation factor and surface water concentrations. Measured fish tissue concentrations were not available for ELS fish; measured tissue concentrations were available for adult fish only.

Potential risk estimates although community likely tolerant of naturally-occurring hydrogeologic conditions

COPEC = chemical of potential ecological concern

HQ = hazard quotient

KMC = Kayenta Mine Complex

LOAEL = lowest observed adverse effect level

MTPY = million tons per year

NOAEL - no observed adverse effect level

OCS = other cumulative sources

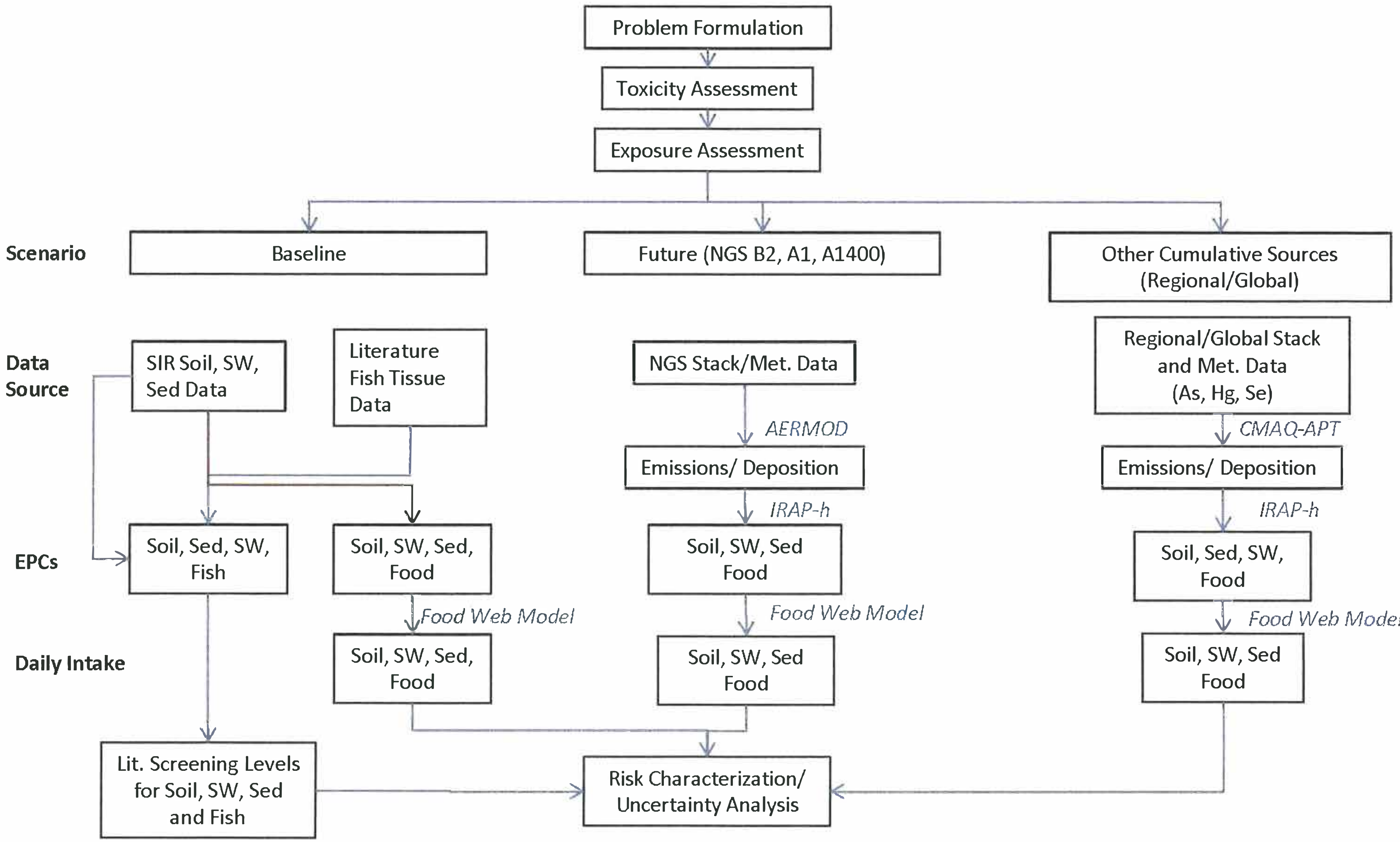
Table 3RA-10 Common Uncertainties Associated with Ecological Risk Assessment

Parameter	Effect on Risk	Comment
Data Quality		
Sufficient Sample Collection	Ability to completely characterize risk	A sufficient number of representative samples must be collected to characterize media in study areas for the risk assessment.
Data Validation – were any samples rejected?	Omitting data that are unusable may under-estimate risk	Detailed QA/QC is conducted on analytical data to determine data usability
Detection Limits-were samples highly diluted?	Over-estimate or under-estimate	If highly diluted data are due to matrix interferences and the data were non-detect, the resulting data could underestimate risks if concentrations are greater than one-half the detection limit, or could overestimate the risk if actual concentrations are less than one-half the detection limit, or could have no effect on risk if the actual data are similar to that reported.
Toxicity Assessment		
Toxicity Value Sources	Overestimate	The representativeness of the selected toxicity data to site-specific receptors is deliberately conservative, as the most toxicologically sensitive endpoints were selected for TRV derivation. While this ensures that the TRV is protective under most conditions, site-specific receptors and bioavailability conditions are still likely to overestimate risk.
Extrapolation of Literature-Derived Toxicity Values to Site-Specific Values	Over-or-underestimate	Conversion factors (UFs) from experimental toxicity endpoints to NOAEL/LOAEL endpoints are meant to be protective under most conditions; however, the appropriateness of the conversion for each individual case is a source of uncertainty. In addition, there are several available systems of uncertainty factors in general use, with varying magnitude of recommended uncertainty.
Physical Stressors Contributing to Adverse Responses	Underestimate	Multiple physical stressors such as temperature extremes, food, water, nutrient limitations, and physical injuries in the environment, may increase sensitivity to contaminant stress, and are not considered. Risk associated with these factors is not easily quantified.
Limited NOAEL/LOAEL Data	Over-or-underestimate	Wildlife TRVs derived from studies conducted using very few species may result in over- or underestimation of reported risk due to lack of knowledge regarding relative sensitivity of test species and ultimately for the wildlife species evaluated.
Exposure Assessment		
Representative Species	Over- or underestimate	Representative species are selected with consideration for their ecological relevance, potential for current or expected future constituent exposure, social and economic importance, current or expected future presence on-site, and the availability of natural history data. The choice of measurement receptors is often limited by available natural history data, precluding the complete evaluation of some relevant site-specific species.
Exposure Parameters	Overestimate	The screening level assessment uses the detected concentration at each sample station to calculate risk estimates. This results in a systematic overestimate of risk: individual mobile receptors will not normally be exposed to one location; and only those individuals of non-mobile receptors at the site will experience such exposure. The use of the mean concentration in the refined estimate represents lower uncertainty. However, uncertainty (over or underestimate) remains due to the variability in foraging and area use by specific receptors.
Exposure Parameters: Ingestion Rates	Underestimation	Ingestion rates are estimated based on allometric equations in the absence of species-specific data. These values introduce uncertainty (under- or overestimation) depending on quantity and/or quality of available food. In general, smaller animals, or individuals, tend to have larger exposure than larger organisms because of higher body weight-specific ingestion rates. Use of larger sized animals may lead to underestimates of ingestion relative to smaller animals. Use of the average reported adult body weight, where available, for the selected receptors in part minimizes this underestimate.
Bioavailability	Overestimate	Bioavailability of constituents is highly dependent on media conditions. The lack of information on site-specific bioavailability introduces significant uncertainty in the risk assessment. Since conservative TRVs are used and an AF of 1 is applied to all data, overall risk will be overestimated for most constituents. Absorption factors will always be less than one, as not all of the constituent ingested is absorbed into the body; some of it is eliminated, metabolized, or sequestered. The fraction absorbed will also differ depending on the chemical form (*e.g.* , valence) and the medium with which it is associated (*e.g.* , constituent adsorbed to clay particles).
Uptake	Underestimate	For most chemicals, uptake factors (bioaccumulation factors, BAFs) are available as central tendency (average) values or regression equations which provide concentration-dependent uptake estimates. While regression equations generally limit this uncertainty, use of central tendency BAFs based on constant values may underestimate uptake for some receptors because of the limited number of test species on which the uptake factors were developed, which may not capture individual species variability for uptake.
Risk Characterization		
Constituents Without Risk Estimates	Overestimate	In an ecological risk assessment, it is common to encounter COPECs for which no TRV exist. For this reason, the ecological COPEC selection process in the risk assessment retained as COPECs all detected analytes although some of the COPECs lack TRVs for any evaluated receptor. Quantitative risk values, therefore, could not be calculated. The absence of toxicity information may underestimate risk, particularly if observed concentrations are high. For some COPECs, partial toxicity information may exist for some receptor classes, but not others. It is inappropriate to extrapolate TRVs between taxonomic classes, but the existence of toxicity information for at least some receptor classes implies risk, albeit of lower confidence than for analytes with complete TRV data.

Figures

This page intentionally left blank

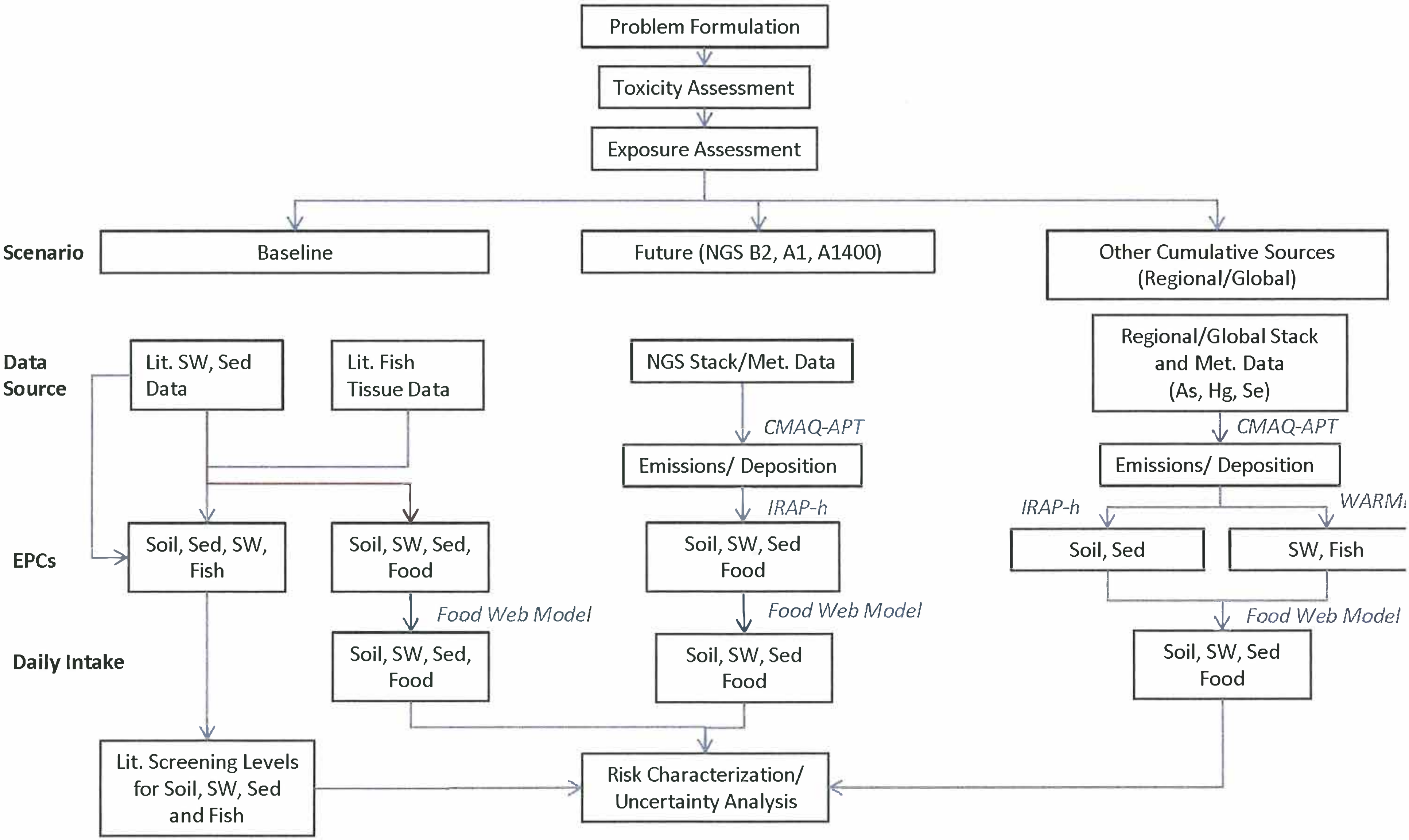
Figure 3RA-1. Navajo Generating Station Near-Field Ecological Risk Assessment Process Summary



Notes: Four primary scenarios were evaluated at NGS for ERA: (1) Baseline, (2) Baseline + Future (NGS B2) (Proposed Action), (3) Baseline + Future (NGS B2) + Other Cumulative Sources (OCS (Total Cumulative), and (4) Baseline + OCS (No Action Alternative).

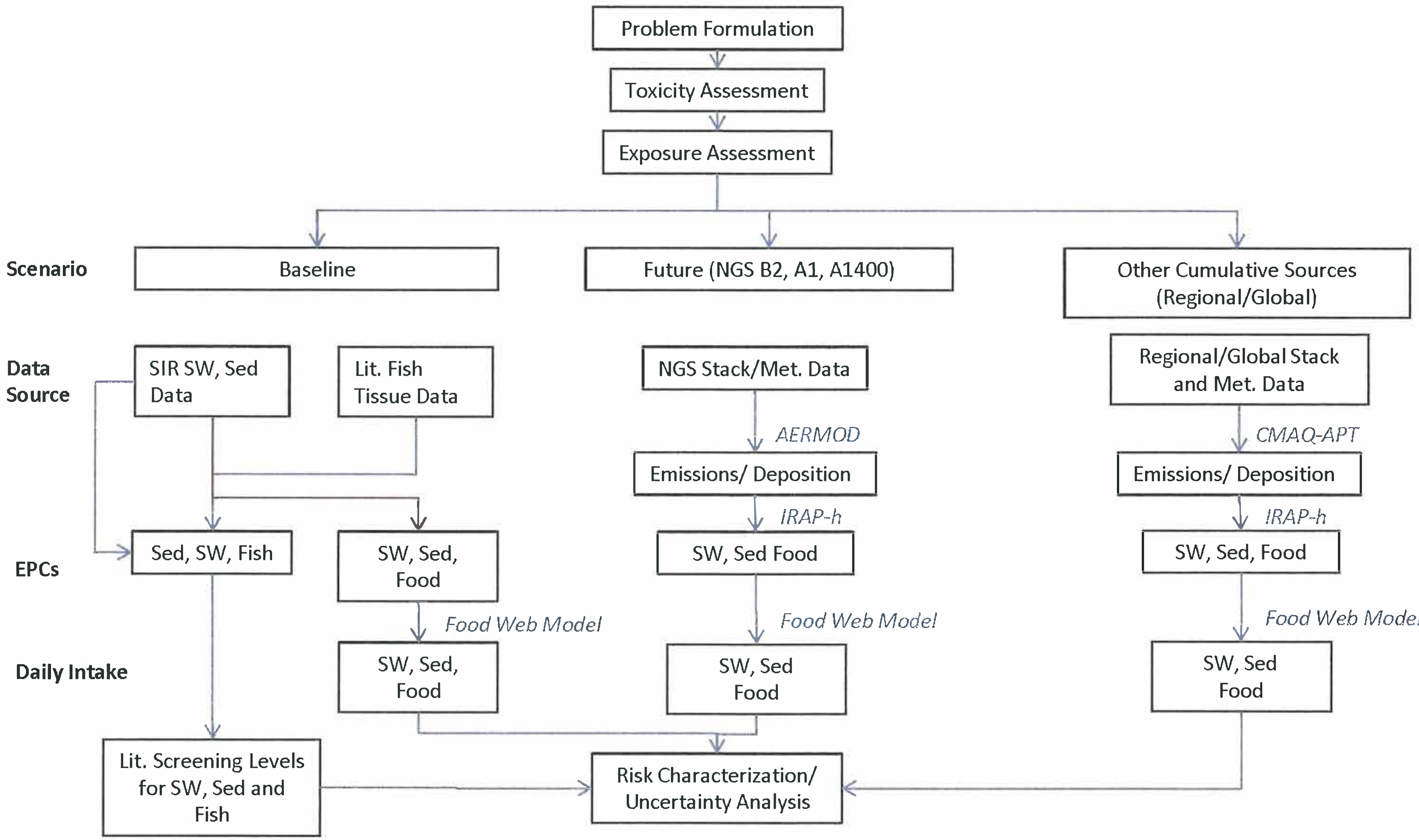
SW = surface water, Sed=sediment, SIR = NGS Near Field Sample Investigation Report; different color lines to aid viewing only

Figure 3RA-2. San Juan River Ecological Risk Assessment Process Summary



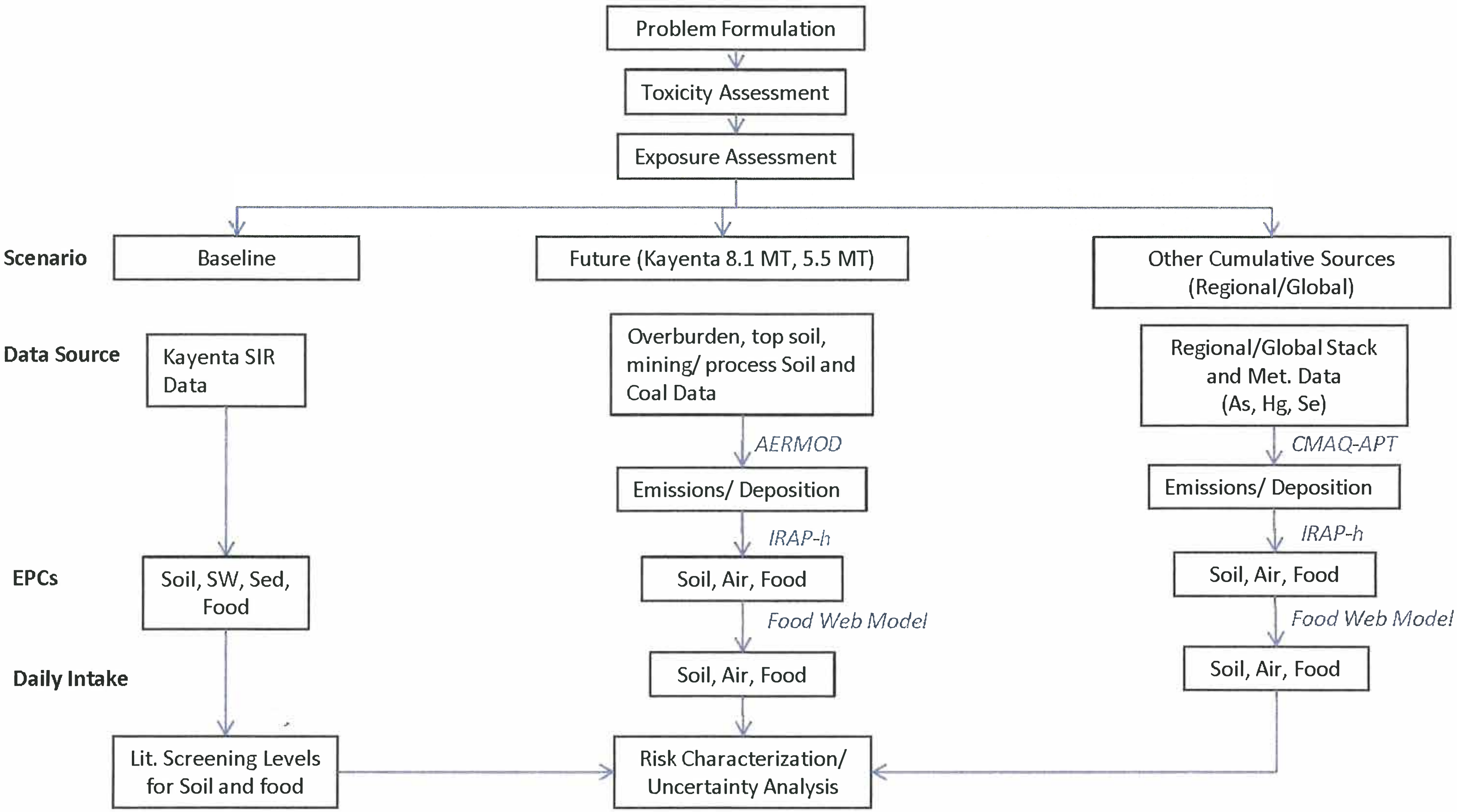
Notes: Four primary scenarios were evaluated at NGS for ERA: (1) Baseline, (2) Baseline + Future (NGS B2) (Proposed Action), (3) Baseline + Future (NGS B2) + Other Cumulative Sources (OCS (Total Cumulative), and (4) Baseline + OCS (No Action Alternative).
SW = surface water, Sed=sediment; different color lines to aid viewing only

Figure 3RA-3. Gap Regions Ecological Risk Assessment Process Summary



Notes: Four primary scenarios were evaluated at NGS for ERA: (1) Baseline, (2) Baseline + Future (NGS B2) (Proposed Action), (3) Baseline + Future (NGS B2) + Other Cumulative Sources (OCS (Total Cumulative), and (4) Baseline + OCS (No Action Alternative).
SW = surface water, Sed=sediment, SW = surface water, SIR = NGS Near Field Sample Investigation Report; different color lines to aid viewing only

Figure 3RA-4. Kayenta Mine Ecological Risk Assessment Process Summary



Notes: Four primary scenarios were evaluated at NGS for ERA: (1) Baseline, (2) Baseline + Future (NGS B2) (Proposed Action), (3) Baseline + Future (NGS B2) + Other Cumulative Sources (OCS (Total Cumulative), and (4) Baseline + OCS (No Action Alternative).
SW = surface water, Sed=sediment, SW = surface water, SIR = KMC Sample Investigation Report

Appendix 3.1-A

Total Nitrogen and Sulfur Deposition at CASTNET Sites in Four National Parks

This page intentionally left blank

Table 3.1-A.1. Annual Total Nitrogen and Sulfur Deposition at Canyonlands NP

	N WET	N DRY	S WET	S DRY
1990	2.565		1.463	
	0.577		0.59	
	1.959		0.987	
	0.668		0.61	
	0.893		0.52	
1995	1.596	0.98	0.897	0.303
	1.323	1.14	0.79	0.295
	2.016	0.913	1.15	0.274
	0.669	1.035	0.47	0.284
	0.882	1.005	0.467	0.251
2000	0.827	1.079	0.377	0.247
	0.987	1.006	0.473	0.251
	1.02	0.945	0.473	0.214
	1.022	1.014	0.37	0.228
	1.604	0.965	0.763	0.218
2005	0.956	0.889	0.46	0.228
	1.367	0.904	0.66	0.207
	1.015	0.961	0.36	0.213
	1.029	0.802	0.43	0.199
	1.035	0.712	0.49	0.168
2010	0.989	0.676	0.37	0.164
	1.169	0.669	0.547	0.168
	0.724	0.716	0.267	0.17
	0.907	0.719	0.367	0.169
2014		0.602		0.154
Average	1.16	0.89	0.60	0.22
Trend	-0.023	-0.023	-0.026	-0.008

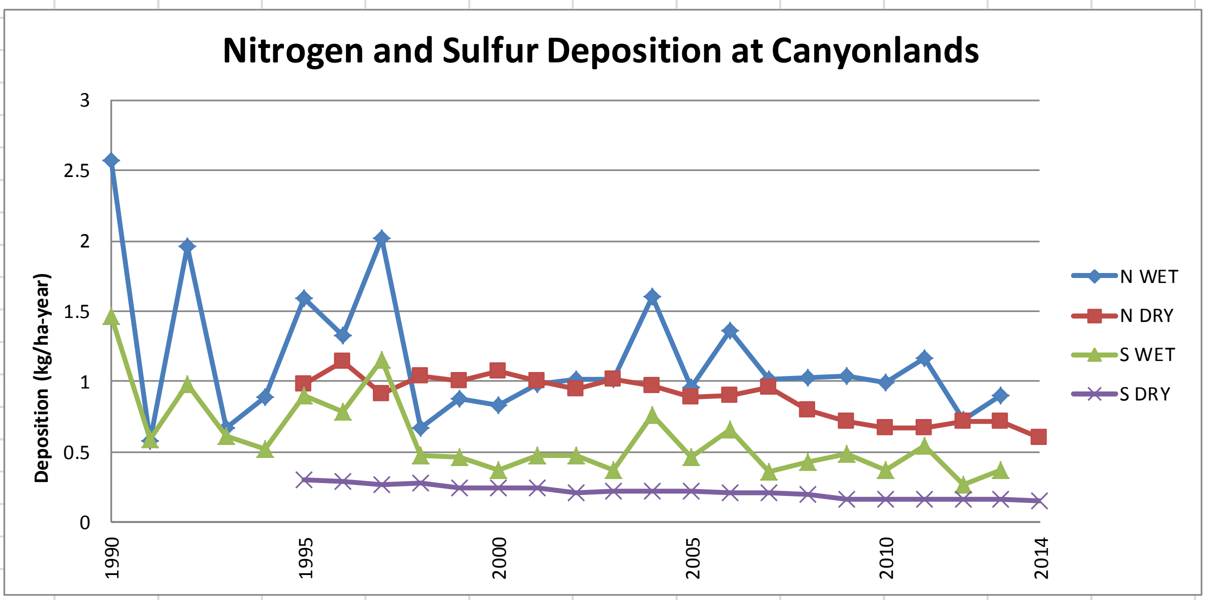


Table 3.1-A.2. Annual Total Nitrogen and Sulfur Deposition at Grand Canyon NP

	N WET	N DRY	S WET	S DRY
1990	1.599	0.942	0.933	0.272
	0.714	0.872	0.513	0.275
	1.163	0.901	0.71	0.269
	0.974	0.752	0.657	0.273
	1.027	0.908	0.553	0.26
1995	1.185	0.905	0.647	0.241
	0.959	1.09	0.52	0.262
	1.377	0.951	0.89	0.257
	0.997	0.608	0.627	0.162
	1.393	0.661	0.613	0.149
2000	1.011	1.005	0.543	0.211
	1.303	0.983	0.64	0.22
	0.912	1.105	0.387	0.211
	1.009	0.865	0.373	0.186
	1.359	0.927	0.737	0.217
2005	1.162	0.892	0.637	0.233
	1.384	0.887	0.61	0.188
	0.886	0.931	0.353	0.206
	1.118	0.763	0.467	0.202
	0.875	0.688	0.383	0.166
2010	2.918	0.619	1.187	0.163
	1.068	0.475	0.49	0.124
	1.29	0.466	0.41	0.121
	1.379	0.628	0.457	0.163
2014		0.619		0.144
Average	1.21	0.82	0.60	0.21
Trend	0.015	-0.014	-0.008	-0.006

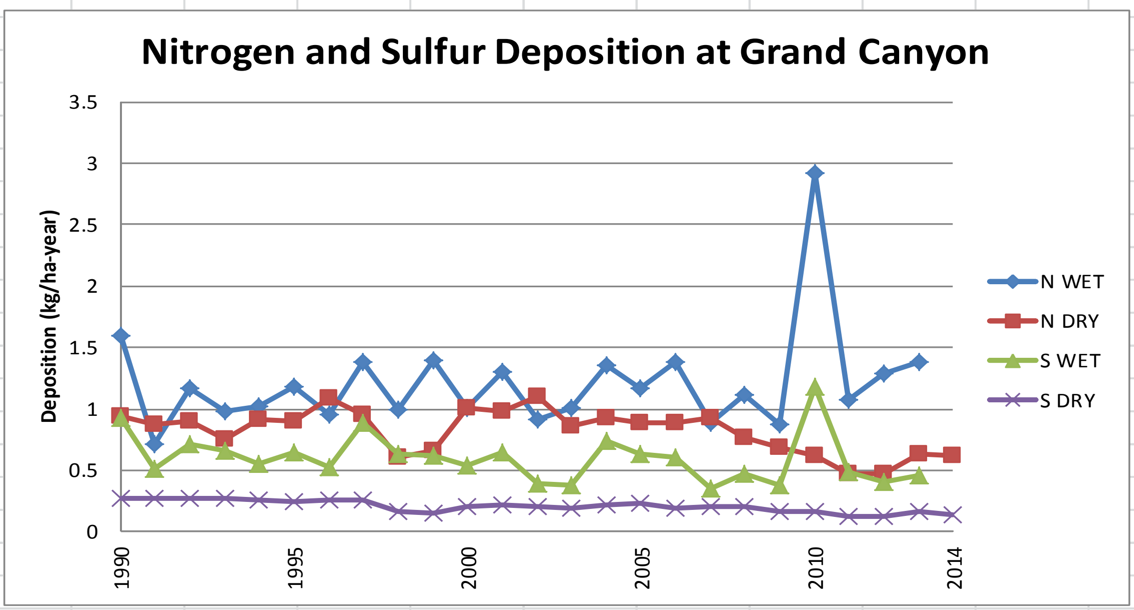


Table 3.1-A.3. Annual Total Nitrogen and Sulfur Deposition at Petrified Forest NP

	N WET	N DRY	S WET	S DRY
1990	1.184		0.99	
	0.495		0.547	
	1.179		1.057	
	0.981		0.96	
	1.261		1.03	
1995	0.571		0.457	
	0.698		0.547	
	0.975		0.973	
	0.876		0.813	
	1.086		0.683	
2000	0.814		0.507	
	0.938		0.62	
	1.152		0.577	
	0.618	1.47	0.307	0.642
	1.598	1.275	0.943	0.602
2005	1.375	1.335	0.743	0.647
	1.357	1.36	0.697	0.667
	1.128	1.411	0.583	0.861
	0.567	1.132	0.283	0.517
	0.797	0.946	0.49	0.373
2010	1.298	0.941	0.61	0.382
	1.629	1.046	0.75	0.395
	1.188	1.043	0.493	0.38
	0.798	0.981	0.283	0.301
2014		0.896		0.262
Average	1.02	1.15	0.66	0.50
Trend	0.011	-0.050	-0.018	-0.041

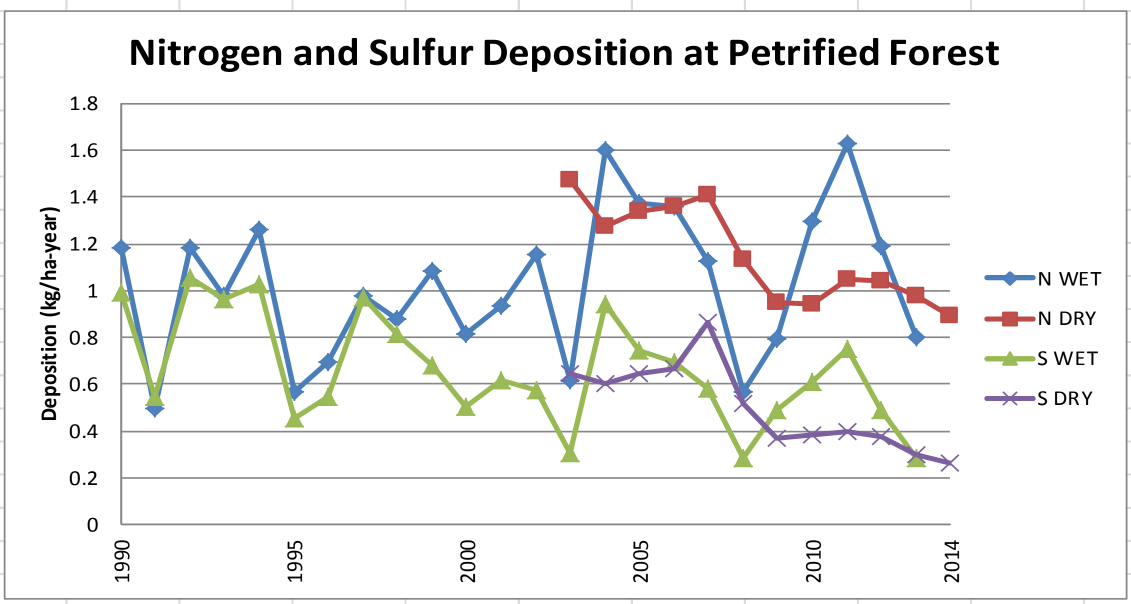
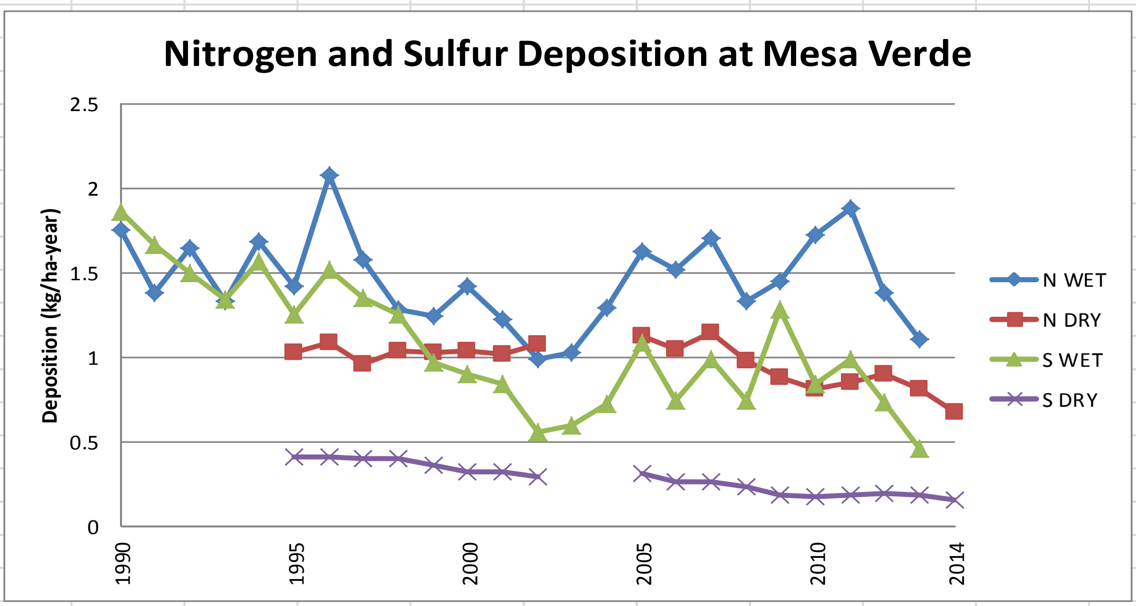


Table 3.1-A.4. Annual Total Nitrogen and Sulfur Deposition at Mesa Verde NP

	N WET	N DRY	S WET	S DRY
1990	1.755		1.863	
	1.375		1.667	
	1.641		1.497	
	1.327		1.343	
	1.684		1.57	
1995	1.415	1.025	1.25	0.41
	2.078	1.082	1.513	0.407
	1.572	0.96	1.35	0.396
	1.28	1.036	1.257	0.398
	1.247	1.022	0.967	0.358
2000	1.415	1.039	0.897	0.319
	1.218	1.018	0.837	0.323
	0.992	1.076	0.553	0.292
	1.029		0.6	
	1.29		0.727	
2005	1.625	1.128	1.083	0.31
	1.517	1.047	0.743	0.267
	1.707	1.144	0.983	0.26
	1.327	0.978	0.74	0.237
	1.445	0.876	1.277	0.189
2010	1.724	0.813	0.837	0.176
	1.88	0.846	0.983	0.183
	1.381	0.901	0.737	0.191
	1.105	0.809	0.457	0.18
2014		0.679		0.155
Average	1.46	0.97	1.07	0.28
Trend	-0.005	-0.014	-0.042	-0.014



Appendix 3.1-B

Atmospheric Deposition Data from the National Dispersion Network Stations

This page intentionally left blank

Table 3.1-B.1. Wet Sulfate Deposition (kg/hectare-year) at Three National Parks National Deposition Network sites.

		GC	Molas	Canyonlands
1990	1990	3.04	5.57	
	1991	1.6	4.37	
	1992	2.24	3.52	
	1993	2.08	4.42	
	1994	1.78	4.79	
1995	1995	2.14	3.5	
	1996	1.68	3.73	
	1997	3.14	4.15	0.12
	1998	1.93	3.68	1.39
	1999	1.92	4.12	1.39
2000	2000	1.74	3.25	1.13
	2001	2.07	2.99	1.42
	2002	1.18	3.09	1.42
	2003	1.15	2.58	1.11
	2004	3.17	3.07	1.98
2005	2005	2.04	3.69	1.38
	2006	1.9	3.13	1.96
	2007	1.1	3.08	1.08
	2008	1.47	2.45	1.29
	2009	1.19	2.41	2.06
2010	2010	3.58	1.97	1.11
	2011	1.54	2.53	1.64
	2012	1.32	1.84	0.8
	2013	1.38	2.46	1.1
2014	2014	0.97	2.23	1.16
		-0.03296	-0.10952	0.012116

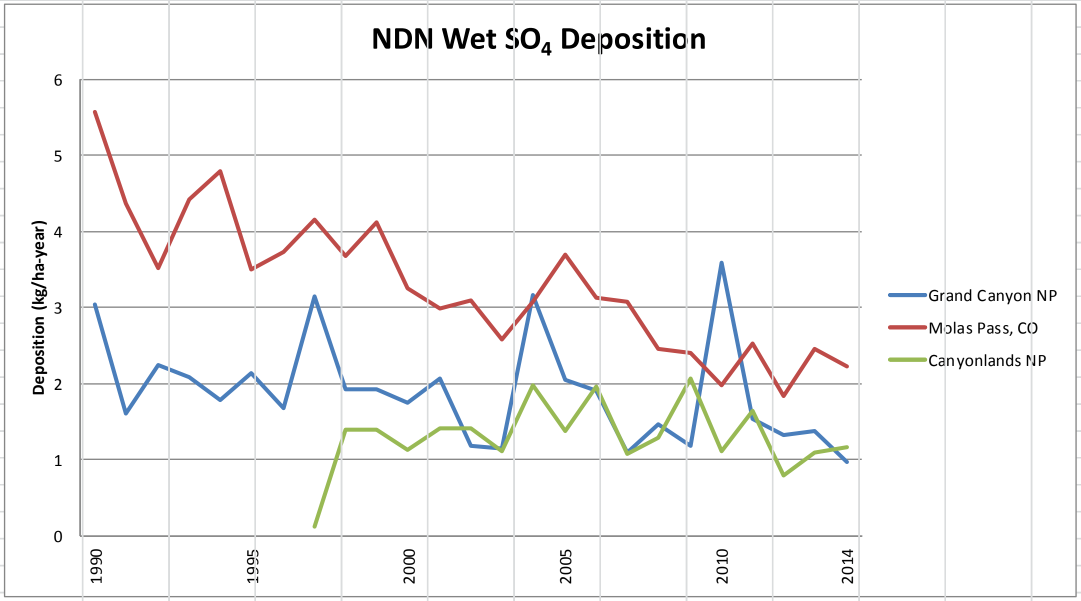
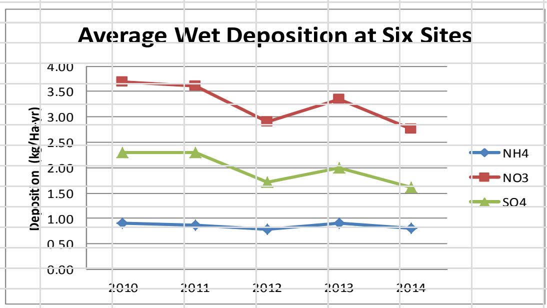


Table 3.1-B.2. Total Annual Wet Deposition (kg/ha-yr) at Six Sites in the Study Area

Site ID	Site	County	Site ID	Data	Year	1	2	3	4	Ca	Mg	K	Na	NH_4	NO_3	Inorganic N	CL	SO_4	H+ (Lab)
AZ03	Grand Canyon National Park-Hopi Point	Coconino	AZ03	Annual	2010	86	98	81	88	2.41	0.447	0.176	0.569	1.91	6.42	2.94	0.9	3.58	0.02
			AZ03	Annual	2011	92	100	95	67	1.13	0.188	0.102	0.309	0.7	2.54	1.12	0.46	1.54	0.01
			AZ03	Annual	2012	96	100	99	82	1.05	0.197	0.09	0.258	0.9	3.02	1.38	0.42	1.32	0.01
			AZ03	Annual	2013	90	100	94	90	0.66	0.132	0.048	0.154	0.92	2.94	1.38	0.25	1.38	0.01
			AZ03	Annual	2014	90	100	95	95	0.62	0.128	0.037	0.177	0.69	2.3	1.06	0.31	0.97	0.01
AZ97	Petrified Forest National Park-Rainbow F	Apache	AZ97	Annual	2010	85	100	84	80	1.16	0.076	0.131	0.222	0.9	2.65	1.3	0.33	1.83	0.01
			AZ97	Annual	2011	89	100	95	69	1.81	0.139	0.141	0.257	1.02	3.7	1.63	0.39	2.25	0.01
			AZ97	Annual	2012	88	100	97	68	1.25	0.078	0.09	0.182	0.81	2.48	1.19	0.28	1.49	0.01
			AZ97	Annual	2013	88	100	84	58	0.66	0.045	0.047	0.094	0.55	1.64	0.79	0.18	0.85	0
			AZ97	Annual	2014	87	100	88	67	0.43	0.037	0.048	0.084	0.46	1.24	0.64	0.15	0.82	0.01
CO96	Molas Pass	San Juan	CO96	Annual	2010	79	100	83	71	0.83	0.08	0.112	0.161	0.68	4.2	1.48	0.32	1.97	0.05
			CO96	Annual	2011	87	100	94	67	1.78	0.169	0.213	0.285	0.9	4.97	1.82	0.4	2.53	0.04
			CO96	Annual	2012	73	100	77	67	0.99	0.092	0.138	0.178	0.99	3.94	1.66	0.28	1.84	0.03
			CO96	Annual	2013	79	100	93	69	2.67	0.2	0.2	0.3	0.92	4.72	1.78	0.47	2.46	0.04
			CO96	Annual	2014	77	100	81	73	1.76	0.147	0.188	0.304	1	4.31	1.76	0.43	2.23	0.04
CO99	Mesa Verde National Park-Chapin Mesa	Montezun	CO99	Annual	2010	83	100	91	61	1.85	0.132	0.095	0.174	0.91	4.5	1.72	0.3	2.51	0.04
			CO99	Annual	2011	83	100	93	73	1.81	0.166	0.099	0.202	1	4.89	1.88	0.29	2.95	0.03
			CO99	Annual	2012	77	100	82	53	3.97	0.24	0.137	0.322	0.76	3.5	1.38	0.23	2.21	0.01
			CO99	Annual	2013	61	100	63	73	4.29	0.288	0.223	0.395	1.32	5.27	2.22	0.45	2.92	0.02
			CO99	Annual	2014	88	100	96	86	1.5	0.141	0.069	0.266	1.16	4.39	1.9	0.28	2.28	0.02
UT09	Canyonlands National Park-Island in the S	San Juan	UT09	Annual	2010	79	100	86	84	1.33	0.175	0.049	0.115	0.56	2.45	0.99	0.16	1.11	0.01
			UT09	Annual	2011	91	100	95	92	2.07	0.218	0.056	0.192	0.78	2.5	1.17	0.19	1.64	0
			UT09	Annual	2012	87	100	83	92	1.35	0.137	0.042	0.117	0.46	1.62	0.73	0.14	0.8	0.01
			UT09	Annual	2013	88	100	92	89	1.91	0.131	0.052	0.138	0.6	1.95	0.91	0.17	1.1	0.01
			UT09	Annual	2014	98	100	95	95	1.26	0.124	0.055	0.16	0.82	2.13	1.12	0.19	1.16	0.01
UT99	Bryce Canyon National Park-Repeater Hill	Garfield	UT99	Annual	2010	85	100	97	83	0.42	0.074	0.064	0.12	0.55	1.94	0.86	0.24	1.4	0.03
			UT99	Annual	2011	83	100	95	67	1.01	0.156	0.101	0.237	0.84	3.03	1.34	0.35	1.65	0.02
			UT99	Annual	2012	88	100	97	75	0.79	0.126	0.123	0.166	0.82	2.82	1.27	0.27	1.47	0.01
			UT99	Annual	2013	88	100	61	71	1.34	0.181	0.083	0.22	1.12	3.58	1.68	0.36	1.91	0.02
			UT99	Annual	2014	86	100	95	85	0.8	0.121	0.083	0.166	0.69	2.2	1.03	0.25	1.14	0.01



	2010	2011	2012	2013	2014
NH4	0.92	0.87	0.79	0.91	0.80
NO3	3.69	3.61	2.90	3.35	2.76
SO4	2.30	2.31	1.72	2.00	1.62

Appendix 3.1-C

Proposed KMC Air Quality Monitoring Report, Summary of Quality Assurance Activities

This page intentionally left blank

Appendix 3.1-C

Summary of 2014 KMC Monitoring Reports and Quality Assurance

A summary of Quality Assurance activities for the PM_{10} monitoring sites at KMC are provided in the 2014 Annual Report: *Annual Report Air Quality Monitoring 2014. Peabody Western Coal Company*. Report submitted by TRC Air Measurements Services, Lakewood, CO. TRC Report No. 203590/002014/Annual

<u>Summary of Data Quality Control</u>

For nearly all of 2014, the ambient air quality monitoring network consisted of twelve (12) PM_{10} samplers at eleven (11) locations with one location supporting sampler collocation for precision determination. In December of 2014, following Office of Surface Mining Reclamation and Enforcement (OSMRE) and Navajo Nation EPA (NNEPA) approval, the monitoring network was reduced to ten (10) PM_{10} samplers at nine (9) locations with one location supporting sampler collocation. In the course of this project, two PM_{10} samplers were removed and one PM_{10} sampler was relocated. TRC is contracted by PWCC to provide technical assistance, PM_{10} gravimetric analysis, agency reporting, and independent quality assurance audits.

The average percent data recovery for all samplers for the monitoring year averaged 97.8% for all sites, which is above the target 80% annual percent recovery.

Procedures used for loading and setting up filter substrates, collecting exposed filters, documenting required field parameters, and the transfer of samples to the laboratory were found to be acceptable. In addition to checking the individual sampler flow rates, the ambient temperature and barometric pressure sensors that are integrated into the samplers' flow system are checked for operational accuracy. All temperature probes and pressure sensors were operating within tolerance limits as defined by the manufacturer.

<u>Summary of Quality Assurance Audits</u>

PM_{10} sampler audits were conducted by TRC using a BGI DeltaCal, which is a NIST-traceable field calibrator. The audit results for the PM_{10} samplers compared the flow reading of each sampler, in actual lpm, to the readings obtained using the primary flow rate standard. All audit procedures followed the methods delineated in the EPA's *Quality Assurance Guideline Document 2.12*, *Monitoring $PM_{2.5}$ in Ambient Air Using Designated Reference or Class I Equivalent Methods*, November 1998, and the EPA's *Code of Federal Regulations (CFR) Title 40 Part 50 Appendix J and Appendix L,* September 16, 2009.

The audit consists of the following four tasks:

1. External Leak Check
2. Ambient and Filter Temperature Sensor Verification
3. Barometric Pressure Sensor Verification
4. Flow Rate Verification

Audit of PM_{10} Samplers for four calendar quarters showed that all monitors passes the flow rate criteria ± 7%

This page intentionally left blank

Appendix 3.1-D

NGS Technical Workgroup Emissions Data for “Bookends” Scenarios

This page intentionally left blank

Table 3.1-D.1. 2020-2044 Emissions from Navajo Generating Station

Scenario	Label	Details	NO_x (tons)	SO_2 (tons)	PM (tons)	CO_2 (tons)	CO (tons)	As (tons)	Hg (tons)	Se (tons)
A1-Actual	A1_A	1500MW, 2 units, TWG A1, Projected Actuals, SCR 2029-2030	199,556	161,978	48,593	332,054,200	242,966	2.21	1.94	37.29
A1-Limits	A1_L	1500MW, 2 units, TWG A1, Projected Limits, SCR 2029-2030	218,022	161,978	48,593	332,054,200	242,966	2.21	1.94	37.29
A2-Actual	A2_A	1689MW, 2 units, TWG A2, Projected Actuals, SCR 2029-2030	224,701	182,387	54,716	373,893,029	273,580	2.49	2.19	41.99
A2-Limits	A2_L	1689MW, 2 units, TWG A2, Projected Limits, SCR 2028-2029	233,090	182,387	54,716	373,893,029	273,580	2.49	2.19	41.99
A3-Actual	A3_A	1689MW, 3 units, TWG A3, Projected Actuals, SCR 2028-2030	219,594	182,387	54,716	373,893,029	273,580	2.49	2.19	41.99
A3-Limits	A3_L	1689MW, 3 units, TWG A3, Projected Limits, SCR 2028-2030	239,292	182,387	54,716	373,893,029	273,580	2.49	2.19	41.99
B1-Actual	B1_A	1773MW, 3 units, TWG B, Projected Actuals, SCR 2030-2032	251,958	191,458	57,437	392,488,064	287,186	2.62	2.30	44.07
B1-Limits	B1_L	1773MW, 3 units, TWG B, Projected Limits, SCR 2027-2029	238,173	191,458	57,437	392,488,064	287,186	2.62	2.30	44.07
B2-Actual	B2_A	2250MW, 3 units, TWG B, Projected Actuals, SCR 2025-2027	251,713	242,966	72,890	498,081,299	364,450	3.32	2.92	55.93
B2-Limits	B2_L	2250MW, 3 units, TWG B, Projected Limits, SCR 2024-2026, +12% curtailments 2024-2026	239,571	237,135	71,141	486,127,348	355,703	3.24	2.85	54.59

Lowest Emissions
Highest Emissions

Table 3.1-D.2. 1500MW, 2 units, TWG A1, Projected Actuals, SCR 2029-2030

Year	Units	MW	mmBTU	NOx (tons)	SO2 (tons)	PM (tons)	CO2 (tons)	CO (tons)	Arsenic (tons)	Mercury (tons)	Selenium (tons)
2020	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2021	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2022	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2023	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2024	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2025	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2026	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2027	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2028	2	1500	129,582,127	13,606	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2029	2	1500	129,582,127	9,071	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2030	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2031	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2032	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2033	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2034	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2035	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2036	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2037	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2038	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2039	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2040	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2041	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2042	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2043	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
2044	2	1500	129,582,127	4,535	6,479	1,944	13,282,168	9,719	0.089	0.078	1.491
Total			**3,239,553,167**	**199,556**	**161,978**	**48,593**	**332,054,200**	**242,966**	**2.213**	**1.944**	**37.287**

NOx Parameters:

Parameter	NOx Emissions	NOx Cap
Pre-SCR (lb/mmBTU)	0.21	-
SCR (lb/mmBTU)	0.07	-
2009-2012 (tons)	91,233	-
2013-2019 (tons)	142,864	-
2009-2044 (tons)	433,654	494,899

Table 3.1-D.3. 2250MW, 3 units, TWG B, Projected Actuals, SCR 2025-2027

Year	Units	MW	mmBTU	NOx (tons)	SO2 (tons)	PM (tons)	CO2 (tons)	CO (tons)	Arsenic (tons)	Mercury (tons)	Selenium (tons)
2020	3	2250	194,373,190	20,409	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2021	3	2250	194,373,190	20,409	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2022	3	2250	194,373,190	20,409	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2023	3	2250	194,373,190	20,409	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2024	3	2250	194,373,190	20,409	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2025	3	2250	194,373,190	15,874	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2026	3	2250	194,373,190	11,338	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2027	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2028	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2029	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2030	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2031	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2032	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2033	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2034	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2035	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2036	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2037	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2038	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2039	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2040	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2041	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2042	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2043	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
2044	3	2250	194,373,190	6,803	9,719	2,916	19,923,252	14,578	0.133	0.117	2.237
Total			**4,859,329,750**	**251,713**	**242,966**	**72,890**	**498,081,299**	**364,450**	**3.319**	**2.916**	**55.931**

NOx Parameters:

Parameter	NOx Emissions	NOx Cap
Pre-SCR (lb/mmBTU)	0.21	-
SCR (lb/mmBTU)	0.07	-
2009-2012 (tons)	91,233	-
2013-2019 (tons)	142,864	-
2009-2044 (tons)	485,811	494,899
2009-2029 (tons)	383,765	416,865

Table 3.1-D.4 NGS Generation Parameters

Parameter	Value	Units
Unit Net Capacity	750	MW
1 unit Heat Input	64,791,063	mmBTU
2 unit Heat Input	129,582,127	mmBTU
3 unit Heat Input (2001-2008 average)[1]	194,373,190	mmBTU
Additional Curtailment Needed	0%	%
	12%	%

NOTES:

[1]Although EPA used the 2001-2012 average heat input in analyzing the TWG Alternatives, the 2001-2008 average is slightly higher and therefore is used in this analysis as a conservative approach.

Table 3.1-D.5. Emission Factors for NGS

Class	Constituent	Actual Projected (lb/mmBTU)	pre-SCR limits (lb/mmBTU)	w/SCR limits (lb/mmBTU)
Criteria	NOx	0.21	0.24	0.07
	SO2	0.10		
	PM	0.03		
	COz	205		
	CO	0.15		
Other	Aresenic	1.37E-06		
	Mercury	1.20E-06		
	Selenium	2.30E-05		

Appendix 3.2-A

Stream Flow Data by Year

This page intentionally left blank

Appendix 3.2-A Exhibit 1

Annual Water Year Natural Flow

The following stream flow data were retrieved from the US Bureau of Reclamation Lower Colorado River database.

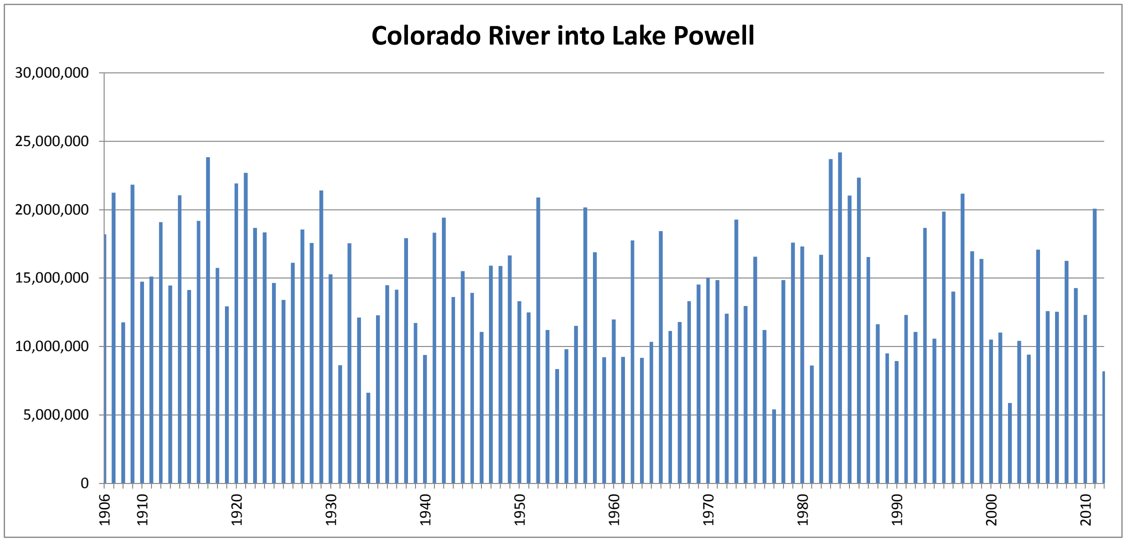
http://www.usbr.gov/lc/region/g4000/NaturalFlow/NaturalFlows1906-2012_withExtensions_1.8.15.xlxs

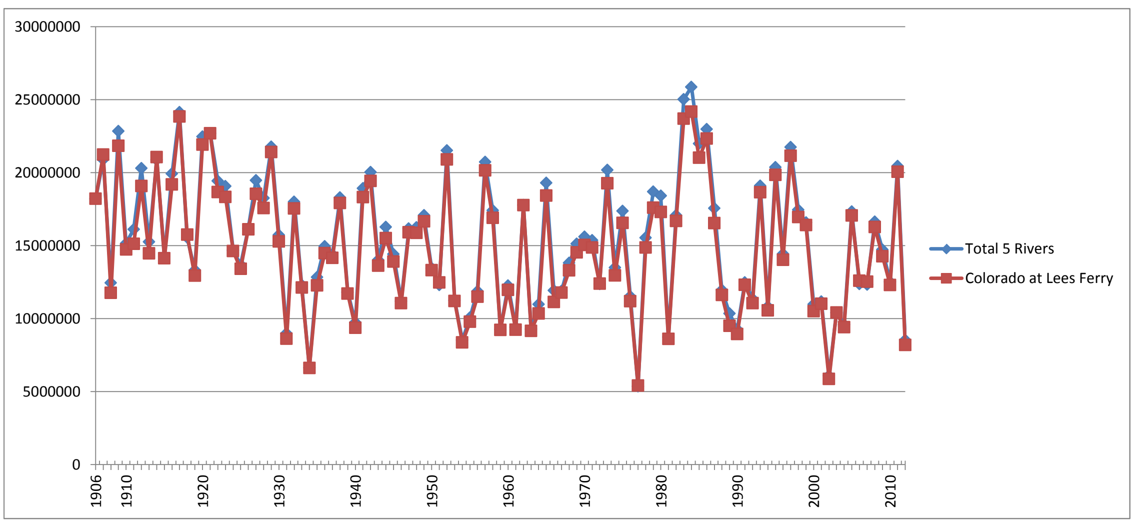
The data represent the total flow for the annual year for the water year listed

The five river flows are added together to represent the inflow to Lake Powell, and this is compared to the data calculated "above Lees Ferry.

USGS Gauge No	09180000	09180500	09315000	09379500	09328500		09380000		
	Dolores River Near Cisco, UT	Colorado River Near Cisco UT	Green River At Green River, UT	San Juan River Near Bluff, UT	San Rafael River Near Green River, UT		Colorado R At Lees Ferry, AZ		
	DoloresRiver.Inflow	GrandValleyReach:GainsAboveCisco.Local Inflow	GreenRAbvGage09315000:GainsAbvGreenRUtah.Local Inflow	SJBelowNavajo:GainsAboveBluff.Local Inflow	SanRafaelRiver.Inflow	Total Upstream	ColoradoRAbvPowell:GainsAboveLeesFerry.Local Inflow	difference	percent difference
	(ac-ft/yr)	(ac-ft/yr)	(ac-ft/yr)	(ac-ft/yr)	(ac-ft/yr)	(ac-ft/yr)	(ac-ft/yr)		
1906	646,693	8,042,414	6,643,543	2,605,715	265,564	18,203,929	18,214,678	-10,749	-0.06
1907	669,219	8,551,631	9,297,303	2,095,016	277,684	20,890,853	21,234,305	-343,452	-1.62
1908	393,988	5,191,180	4,734,316	1,977,570	151,664	12,448,718	11,773,952	674,766	5.73
1909	991,606	9,030,357	9,129,833	3,407,667	291,752	22,851,215	21,841,427	1,009,788	4.62
1910	766,330	6,587,653	5,380,917	2,109,325	316,214	15,160,439	14,736,670	423,769	2.88
1911	749,773	7,251,910	4,751,681	3,147,987	214,614	16,115,965	15,125,081	990,884	6.55
1912	1,041,169	9,363,498	6,708,358	2,941,102	248,514	20,302,641	19,082,127	1,220,514	6.40
1913	927,312	6,098,750	6,023,589	1,954,630	252,014	15,256,295	14,472,192	784,103	5.42
1914	928,609	8,898,320	7,815,479	2,902,903	327,266	20,872,577	21,066,767	-194,190	-0.92
1915	751,370	6,026,415	4,215,434	3,107,135	166,865	14,267,219	14,137,603	129,616	0.92
1916	1,406,693	8,343,066	6,481,466	3,448,637	251,256	19,931,118	19,187,542	743,576	3.88
1917	1,248,660	9,661,928	9,157,766	3,680,224	394,373	24,142,951	23,849,259	293,692	1.23
1918	338,141	7,353,690	5,890,585	1,776,327	200,844	15,559,587	15,750,724	-191,137	-1.21
1919	782,963	5,884,218	3,945,103	2,552,720	163,229	13,328,233	12,951,469	376,764	2.91
1920	1,337,523	9,908,922	6,749,065	4,176,213	293,382	22,465,105	21,927,976	537,129	2.45
1921	1,398,842	9,802,845	7,971,213	3,205,307	313,426	22,691,633	22,703,070	-11,437	-0.05
1922	1,190,422	7,983,178	7,088,574	2,931,300	239,700	19,433,174	18,669,586	763,588	4.09
1923	950,325	8,245,998	7,075,270	2,538,648	263,991	19,074,232	18,343,663	730,569	3.98
1924	687,991	6,930,321	4,550,711	2,309,939	200,571	14,679,533	14,639,094	40,439	0.28
1925	680,805	6,042,821	4,732,167	2,045,633	184,456	13,685,882	13,410,821	275,061	2.05
1926	761,920	7,660,758	5,083,541	2,424,229	249,047	16,179,495	16,114,020	65,475	0.41
1927	1,180,596	8,471,257	5,976,351	3,577,240	275,372	19,480,816	18,551,860	928,956	5.01
1928	864,615	8,624,038	6,587,104	1,917,306	266,892	18,259,955	17,577,859	682,096	3.88
1929	1,296,763	9,653,889	7,273,593	3,245,672	299,861	21,769,778	21,407,051	362,727	1.69
1930	1,026,988	7,244,173	5,329,622	1,926,900	202,373	15,730,056	15,283,505	446,551	2.92
1931	604,002	3,978,451	3,118,766	1,164,453	122,224	8,987,896	8,631,719	356,177	4.13
1932	1,155,733	7,857,118	5,611,114	3,171,598	210,448	18,006,011	17,545,522	460,489	2.62
1933	474,350	5,821,050	4,361,677	1,486,420	143,701	12,287,198	12,130,063	157,135	1.30
1934	252,160	3,329,525	2,025,649	955,529	69,374	6,632,237	6,627,514	4,723	0.07
1935	728,892	5,881,783	3,691,415	2,390,755	141,793	12,834,638	12,280,022	554,616	4.52
1936	799,892	7,065,645	5,062,508	1,838,812	187,466	14,954,323	14,485,382	468,941	3.24
1937	906,200	5,824,235	4,942,080	2,537,600	200,723	14,410,838	14,161,753	249,085	1.76
1938	1,055,000	8,731,453	5,622,092	2,650,286	239,383	18,298,214	17,920,064	378,150	2.11
1939	525,300	5,490,650	4,170,414	1,475,396	145,444	11,807,204	11,718,056	89,148	0.76
1940	604,100	4,681,476	3,134,285	1,195,415	123,891	9,739,167	9,380,279	358,888	3.83
1941	1,480,400	7,791,509	4,975,030	4,465,625	219,778	18,932,342	18,319,340	613,002	3.35
1942	1,753,100	8,928,755	5,807,681	3,301,402	246,341	20,037,279	19,428,259	609,020	3.13
1943	757,300	6,420,332	5,051,498	1,623,143	158,596	14,010,869	13,624,479	386,390	2.84
1944	1,150,200	7,124,088	5,281,599	2,456,848	258,548	16,271,283	15,512,509	758,774	4.89
1945	810,000	6,671,738	4,899,277	1,865,600	170,719	14,417,334	13,912,713	504,621	3.63
1946	454,000	5,243,989	4,296,596	1,062,661	142,397	11,199,643	11,062,728	136,915	1.24
1947	659,600	7,277,768	6,312,592	1,708,623	213,563	16,172,146	15,916,279	255,867	1.61
1948	1,005,600	7,649,066	4,962,104	2,485,975	149,330	16,252,075	15,880,189	371,886	2.34
1949	970,900	7,459,074	5,737,381	2,695,622	212,008	17,074,985	16,662,172	412,813	2.48
1950	527,500	5,378,390	6,351,509	1,083,747	117,244	13,458,390	13,317,921	140,469	1.05
1951	301,500	5,413,946	5,553,574	908,635	129,044	12,306,699	12,485,833	-179,134	-1.43
1952	1,242,500	9,279,848	7,808,459	2,811,219	384,143	21,526,169	20,900,043	626,126	3.00
1953	433,900	5,340,592	4,183,832	1,157,854	134,097	11,250,275	11,204,001	46,274	0.41
1954	338,100	3,470,822	3,399,268	1,236,743	89,788	8,534,721	8,368,141	166,580	1.99
1955	509,400	4,631,302	3,635,266	1,203,881	90,536	10,070,385	9,795,470	274,915	2.81
1956	410,500	5,063,190	5,213,508	1,109,104	86,833	11,883,135	11,505,097	378,038	3.29
1957	1,230,000	10,090,575	6,362,342	2,847,427	206,007	20,736,351	20,159,803	576,548	2.86
1958	1,221,700	7,738,592	5,390,605	2,799,096	263,213	17,413,206	16,899,937	513,269	3.04

1959	292,400	4,504,765	3,508,527	873,676	71,424	9,250,792	9,232,537	18,255	0.20
1960	638,500	5,700,298	3,826,291	2,009,081	91,961	12,266,131	11,974,847	291,284	2.43
1961	499,000	4,546,229	2,810,547	1,454,632	100,583	9,410,991	9,247,778	163,213	1.76
1962	729,600	8,219,900	6,858,586	1,783,986	177,601	17,769,673	17,769,350	323	0.00
1963	384,300	4,035,058	3,477,596	1,269,722	109,452	9,276,128	9,169,052	107,076	1.17
1964	463,800	4,843,768	4,461,292	1,093,197	120,526	10,982,583	10,355,450	627,133	6.06
1965	974,900	8,235,451	7,168,872	2,681,258	234,588	19,295,069	18,433,671	861,398	4.67
1966	666,200	5,065,547	4,116,898	1,974,554	109,818	11,933,017	11,139,763	793,254	7.12
1967	398,500	4,807,225	5,285,924	1,267,558	129,745	11,888,952	11,786,991	101,961	0.87
1968	677,200	5,973,949	5,267,455	1,767,598	133,968	13,820,170	13,307,287	512,883	3.85
1969	754,800	6,453,617	5,600,397	2,108,031	217,228	15,134,073	14,543,476	590,597	4.06
1970	715,300	7,578,359	5,178,217	1,978,286	162,530	15,612,692	15,040,894	571,798	3.80
1971	530,892	6,753,533	6,612,565	1,362,751	109,456	15,369,197	14,867,363	501,834	3.38
1972	273,084	4,975,214	5,746,507	1,277,499	101,726	12,374,030	12,398,388	-24,358	-0.20
1973	1,390,453	8,122,698	6,321,681	4,122,040	227,421	20,184,293	19,270,770	913,523	4.74
1974	507,637	5,939,361	6,013,343	922,718	117,541	13,500,600	12,965,334	535,266	4.13
1975	1,077,731	7,069,475	6,297,057	2,757,794	175,264	17,377,321	16,563,774	813,547	4.91
1976	563,562	4,867,706	4,656,643	1,363,164	74,764	11,525,839	11,199,060	326,779	2.92
1977	199,360	2,624,826	1,890,009	605,169	48,468	5,367,832	5,417,868	-50,036	-0.92
1978	911,536	7,181,371	5,776,823	1,535,119	135,368	15,540,217	14,870,955	669,262	4.50
1979	1,276,175	8,443,914	5,096,371	3,717,601	164,769	18,698,830	17,601,101	1,097,729	6.24
1980	1,217,069	7,894,041	6,222,018	2,842,829	238,171	18,414,128	17,305,967	1,108,161	6.40
1981	392,715	3,888,543	3,315,140	1,026,552	104,924	8,727,874	8,620,193	107,681	1.25
1982	908,556	7,387,432	6,232,095	2,362,114	189,869	17,080,066	16,696,939	383,127	2.29
1983	1,665,017	10,984,760	9,071,994	2,885,688	421,405	25,028,864	23,697,872	1,330,992	5.62
1984	1,471,630	12,546,804	9,005,019	2,400,607	449,052	25,873,112	24,182,778	1,690,334	6.99
1985	1,449,881	10,494,720	6,547,270	3,226,754	263,969	21,982,594	21,024,590	958,004	4.56
1986	1,209,323	9,846,093	8,634,152	3,067,612	218,446	22,975,626	22,335,681	639,945	2.87
1987	1,331,637	7,681,756	5,074,287	3,347,924	132,310	17,567,914	16,543,449	1,024,465	6.19
1988	613,518	5,220,672	4,231,925	1,779,799	105,783	11,951,697	11,622,839	328,858	2.83
1989	552,182	4,795,509	3,407,034	1,509,336	84,179	10,348,240	9,507,957	840,283	8.84
1990	346,450	4,018,631	3,478,877	1,348,540	74,549	9,267,047	8,945,318	321,729	3.60
1991	620,381	5,678,010	4,231,830	1,825,465	122,728	12,478,414	12,317,705	160,709	1.30
1992	783,323	5,240,093	3,249,701	1,972,987	110,981	11,357,085	11,066,553	290,532	2.63
1993	1,523,705	8,994,667	5,551,736	2,858,731	171,871	19,100,710	18,663,096	437,614	2.34
1994	611,314	5,113,083	3,452,204	1,524,662	115,806	10,817,069	10,570,318	246,751	2.33
1995	1,164,960	9,622,162	6,714,087	2,645,742	219,225	20,366,176	19,854,901	511,275	2.58
1996	455,066	7,085,844	5,882,090	868,137	145,677	14,436,814	14,026,588	410,226	2.92
1997	1,241,373	9,618,818	7,837,148	2,847,043	201,677	21,746,059	21,164,104	581,955	2.75
1998	884,764	7,238,870	7,425,952	1,707,776	194,886	17,452,248	16,956,560	495,688	2.92
1999	820,472	6,569,839	6,511,373	2,504,754	174,563	16,581,001	16,414,579	166,422	1.01
2000	557,578	5,384,992	3,902,442	1,027,896	102,723	10,975,631	10,510,093	465,538	4.43
2001	556,913	4,938,636	3,775,986	1,791,415	111,080	11,174,030	11,025,809	148,221	1.34
2002	225,577	2,768,138	2,503,540	515,383	75,419	6,088,057	5,871,677	216,380	3.69
2003	446,388	5,023,344	3,744,651	1,091,138	102,504	10,408,025	10,425,143	-17,118	-0.16
2004	553,283	4,298,410	3,217,501	1,433,542	94,241	9,596,977	9,417,446	179,531	1.91
2005	1,073,411	6,950,439	6,281,037	2,838,002	194,591	17,337,480	17,070,158	267,322	1.57
2006	507,026	5,719,200	4,620,492	1,319,662	209,949	12,376,329	12,596,918	-220,589	-1.75
2007	776,226	5,671,338	3,704,595	2,014,244	163,833	12,330,236	12,538,073	-207,837	-1.66
2008	955,974	8,279,787	4,958,420	2,304,118	140,864	16,639,163	16,271,388	367,775	2.26
2009	631,912	7,056,545	5,380,288	1,524,285	134,012	14,727,042	14,273,798	453,244	3.18
2010	702,701	5,719,970	4,456,115	1,512,024	124,566	12,515,376	12,302,267	213,109	1.73
2011	826,954	8,962,876	9,074,462	1,278,190	310,723	20,453,205	20,066,140	387,065	1.93
2012	496,657	3,520,326	3,438,107	949,196	131,091	8,535,377	8,193,971	341,406	4.17
						0			
1906-2012 a	811,963	6,791,073	5,389,345	2,110,022	183,340	15,285,743	14,870,319	415,424	2.79


Colorado River into Lake Powell
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
1906
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010


30000000
25000000
20000000
15000000
10000000
5000000
0
1906
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Total 5 Rivers
Colorado at Lees Ferry

This page intentionally left blank

Appendix 3.2-B

Precipitation and Temperature Data

This page intentionally left blank

Appendix 3.2-B Exhibit 1

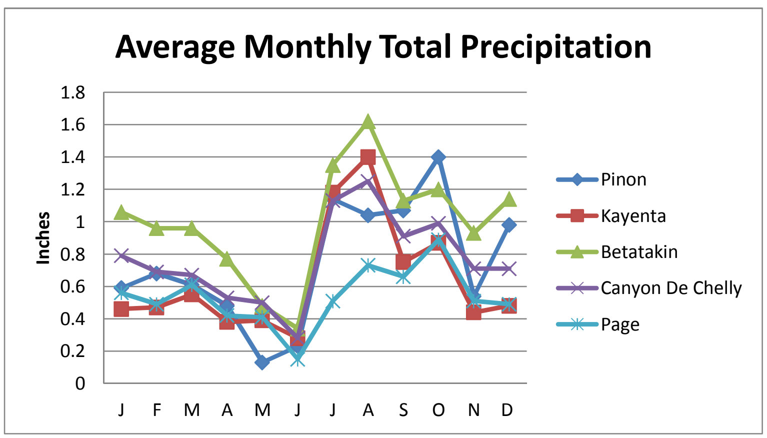
Montly Temperature and Precipitation Data for Five sites.
Data Obtained from Western Region Climate Center

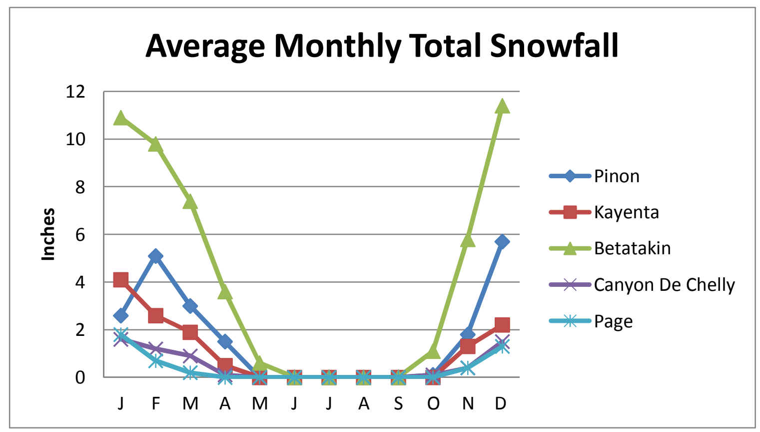
		J	F	M	A	M	J	J	A	S	O	N	D	Ann
Pinon AZ	1959-1974													
	Average Max. Temperature (F)	41.4	48.8	54.7	63	74.2	83.5	89.9	87.1	80	67.9	55.1	42.8	65.7
	Average Min. Temperature (F)	11.9	20	21.6	26.6	35.3	42.7	57.3	54.8	44.8	34.4	24.5	15.8	32.5
	Average Total Precipitation (in.)	0.59	0.68	0.61	0.48	0.13	0.23	1.14	1.04	1.07	1.4	0.54	0.98	8.88
	Average Total SnowFall (in.)	2.6	5.1	3	1.5	0	0	0	0	0	0.1	1.8	5.7	19.7
	Average Snow Depth (in.)	1	0	0	0	0	0	0	0	0	0	0	1	0
Kayenta, A	1915-1978													
	Average Max. Temperature (F)	41.7	48.4	57.4	67.1	76.9	87.3	91.5	88.6	82.3	69.5	54.4	43.6	67.4
	Average Min. Temperature (F)	17	23.4	29.1	36	44.7	52.6	60	58.3	50	38.8	26.7	19.6	38
	Average Total Precipitation (in.)	0.46	0.47	0.55	0.38	0.39	0.28	1.18	1.4	0.75	0.87	0.44	0.48	7.66
	Average Total SnowFall (in.)	4.1	2.6	1.9	0.5	0	0	0	0	0	0	1.3	2.2	12.8
	Average Snow Depth (in.)	1	0	0	0	0	0	0	0	0	0	0	0	0
Betatakin,	1939-2015													
	Average Max. Temperature (F)	39.8	43.2	50.4	60.1	70.8	81.5	86	83.1	76	63.7	49.4	40.4	62
	Average Min. Temperature (F)	20.8	23.2	27.6	33.9	42.9	52.5	58.3	56.6	50.6	40.1	29	21.9	38.1
	Average Total Precipitation (in.)	1.06	0.96	0.96	0.77	0.48	0.34	1.35	1.62	1.13	1.2	0.93	1.14	11.94
	Average Total SnowFall (in.)	10.9	9.8	7.4	3.6	0.6	0	0	0	0	1.1	5.8	11.4	50.8
Canyon De	1970-2013													
	Average Max. Temperature (F)	44.2	51	60.4	69.1	78.6	89.2	92.5	89.4	82.6	70.2	55.8	44.9	69
	Average Min. Temperature (F)	19.1	23.6	29.5	35.7	43.8	52	59.9	58.7	49.6	37.6	27.1	19.2	38
	Average Total Precipitation (in.)	0.79	0.69	0.67	0.53	0.5	0.28	1.13	1.25	0.91	0.99	0.71	0.71	9.14
	Average Total SnowFall (in.)	1.6	1.2	0.9	0.1	0	0	0	0	0	0.1	0.4	1.5	5.9
	Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	
Page	1957-2012													
	Average Max. Temperature (F)	43.5	50.6	60	69.4	80.1	91.2	96.6	93.3	84.7	71	55.1	44.1	70
	Average Min. Temperature (F)	25.6	30.7	37.3	44.5	53.7	63.4	69.8	67.6	59.2	47.3	35.3	26.7	46.8
	Average Total Precipitation (in.)	0.56	0.49	0.61	0.42	0.41	0.15	0.51	0.73	0.66	0.89	0.51	0.49	6.44
	Average Total SnowFall (in.)	1.8	0.7	0.2	0	0	0	0	0	0	0	0.4	1.3	4.3
	Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3.2-B Exhibit 1

Montly Temperature and Precipitation Data for Five sites.
Data Obtained from Western Region Climate Center

	J	F	M	A	M	J	J	A	S	O	N	D	Ann
Pinon	0.59	0.68	0.61	0.48	0.13	0.23	1.14	1.04	1.07	1.4	0.54	0.98	8.88
Kayenta	0.46	0.47	0.55	0.38	0.39	0.28	1.18	1.4	0.75	0.87	0.44	0.48	7.66
Betatakin	1.06	0.96	0.96	0.77	0.48	0.34	1.35	1.62	1.13	1.2	0.93	1.14	11.94
Canyon De Chelly	0.79	0.69	0.67	0.53	0.5	0.28	1.13	1.25	0.91	0.99	0.71	0.71	9.14
Page	0.56	0.49	0.61	0.42	0.41	0.15	0.51	0.73	0.66	0.89	0.51	0.49	6.44
Pinon	2.6	5.1	3	1.5	0	0	0	0	0	0.1	1.8	5.7	19.7
Kayenta	4.1	2.6	1.9	0.5	0	0	0	0	0	0	1.3	2.2	12.8
Betatakin	10.9	9.8	7.4	3.6	0.6	0	0	0	0	1.1	5.8	11.4	50.8
Canyon De Chelly	1.6	1.2	0.9	0.1	0	0	0	0	0	0.1	0.4	1.5	5.9
Page	1.8	0.7	0.2	0	0	0	0	0	0	0	0.4	1.3	4.3



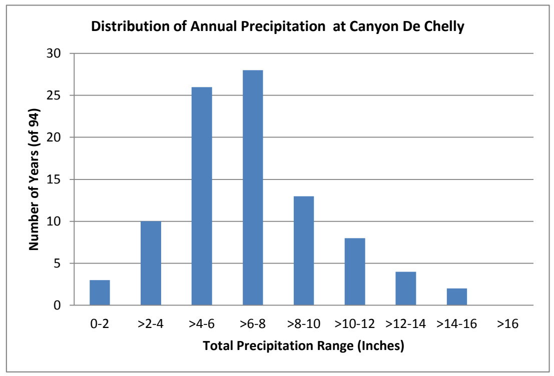


Appendix 3.2-B Exhibit 2
Precipitation Distribution at Canyon De Chelly and Betatakin

YEAR(S)	Canyon De Chelly Annual Total Precip		Betatakin Annual Total Precip
1908	1.78	k	
1909	10.62		
1910	6.83		
1911	13.68		
1912	6.83		
1913	7.95		
1914	9.55	a	
1915	12.09		
1916	7.12	a	
1917	5.23		
1918	9.28		
1919	8.18		
1920	7.44		
1921	6.67		
1922	9.42		
1923	13.12		
1924	7.44		
1925		k	
1926		h	
1927	8.67		
1928		h	
1929		l	
1930		l	
1931		l	
1932		l	
1933		l	
1934		l	
1935		f	
1936	4.93	b	
1937	9.43	a	
1938	4.27	d	
1939	5.02		8.25
1940	14.97		15.95
1941	17.05	b	14.72
1942	9.64		5.84
1943	15.68	a	9.86
1944	10.21		9.99
1945	6.77		
1946	9.37		13.01
1947	11.51		11
1948	12.04		9.15
1949	8.35		
1950	3.52		6.58
1951	7.14		12.58
1952	10.76		11.11
1953	7.02		11
1954	7.34		12.23
1955	5.28		8.13
1956	5.42		6.47
1957	13.90		17.86
1958	6.34		9.44
1959	9.22		10.76
1960	6.95		11.13
1961	8.89		12.86
1962	7.22		8.33
1963	10.80		8.63

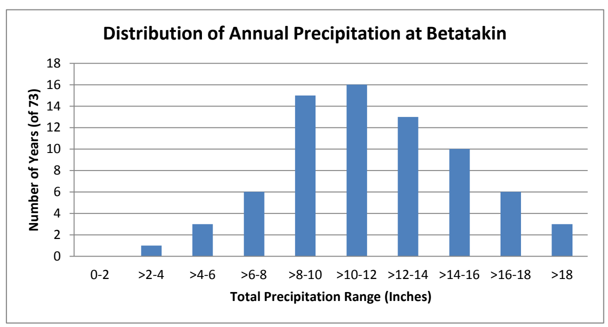
Canyon De Chelly Distribution

0-2	>2-4	>4-6	>6-8	>8-10	>10-12	>12-14	>14-16
91	81	55	27	14	6	2	0
3	10	26	28	13	8	4	2



Betatakin Distribution

0-2	>2-4	>4-6	>6-8	>8-10	>10-12	>12-14	>14-16	>16-18	>18
73	73	72	69	63	48	32	19	9	3
0	1	3	6	15	16	13	10	6	3



Appendix 3.2-B Exhibit 2
Precipitation Distribution at Canyon De Chelly and Betatakin

YEAR(S)	Canyon De Chelly Annual Total Precip		Betatakin Annual Total Precip
1964	11.48		10.88
1965	14.10		18.79
1966	7.61		11.29
1967	8.09		12.07
1968	7.48	a	8.77
1969	4.68	d	10.08
1970		k	8.84
1971	6.49	a	10.33
1972	9.61		16.39
1973	8.59		9.28
1974	7.97		8.27
1975	5.07		15.57
1976	5.96		12.79
1977	7.75		6.72
1978	10.68		13.31
1979	8.93		11.65
1980	9.93		12.36
1981	9.16		12.36
1982	17.60		20.25
1983	12.22		15.89
1984	10.57		13.69
1985	11.81		15.11
1986	8.14		11.73
1987	11.38		15.73
1988	15.03		16.16
1989	3.29		7.11
1990	10.64		14.06
1991	8.81		10.29
1992	10.19	a	15.59
1993		c	16.63
1994	8.31		11.66
1995	6.58	b	11.17
1996	6.07	a	8.55
1997	13.87		16.39
1998	8.23	a	16.64
1999	9.11		10.01
2000	9.36		9.1
2001	6.56		6.18
2002	5.47		3.59
2003	7.14		5.88
2004	8.72		18.52
2005	9.35		14.81
2006	7.73		12.62
2007	9.43		8.69
2008	10.36		15.75
2009	6.02		7.35
2010	12.11		12.82
2011	9.20		8.09
2012	3.92		10.47
2013	8.50		13.68
2014	7.46		5.54
2015	6.51	g	6.97

Appendix 3.2-B Exhibit 3 Records of Precipitation at Canyon De Chelly

YEAR(S)		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YEAR(S)	OCT	NOV	DEC	ANN
1908		----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1908	----- z	----- z	1.78 a	1.78 k
1909		0.14	0.25	0.68	0.2	0.01	0	2.14	3.67	1.63	1909	0	0.47	1.43	10.62
1910	1910	0.37	0.27	0.12	0.25	0	0	1.96	1.53	0.14	1910	0.75	0.98	0.46	6.83
1911		0.48	1.44	1.44	0.19	0.01	0.97	3.59	1.4	2.8	1911	1.23	0.05	0.08	13.68
1912		0.03	0	0.94	0.65	0.03	0.71	1.02	1.77	0.14	1912	1.16	0.26	0.12	6.83
1913		0.15	0.74	0.15	0.89	0.02	0.26	1.28	0.51	1.13	1913	1.56	0.81	0.45	7.95
1914		0.33	0.25	0.18	0.18	0.36 c	0.16	4.41	1.28	0.08 h	1914	1.77	0	0.63	9.55 a
1915		0.86	0.7	0.06	1.48	0.92	0.41	5.07	1.27	0.21	1915	0	0.38	0.73	12.09
1916		0.26 g	0.16	0.71	0.89	0.11	0	1.25	1.01	1.09	1916	1.78	0	0.12	7.12 a
1917		1.9	0.24	0.02	0.06	0.34	0	1.1	0.36	1.14	1917	0.07	0	0	5.23
1918		0.6	0.49	0.13	0.03	0.17	0.78	3.22	1.39	0.35	1918	0.79	0.68	0.65	9.28
1919		0.06	0.36	0.97	0.57	1.3	0	1.25	0.54 e	1.18	1919	1.24	0.68	0.03	8.18
1920	1920	0.99	1.78	0.36	0.22	0.74	0.58	0.39	0.58	0.63	1920	1.11	0.05	0.01	7.44
1921		0.25	0	0.07	0	0	1.19	0.9 b	1.89	0.04	1921	1.31	0.09	0.93	6.67
1922		0.62 a	0 b	3.82 a	0.02 a	0.29	0.23 a	1.46	2.27	0	1922	0.23	0.43	0.05	9.42
1923		0.47	0.32	0.07	0.46	0.58	0	1.16	2.57	3.13	1923	0.8	1.3	2.26	13.12
1924		0	0	0.09	1.12	0	0	2.43	1.26	1.21	1924	0.74	0.07	0.52	7.44
1925		0.19	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1925	----- z	----- z	----- z	0.19 k
1926		----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1.82	1926	0.71	0.44	1.76	4.73 h
1927		0.1	1.17	1.04	0.3	0	2.5	0.08	0.88	1.56	1927	0	0.67	0.37	8.67
1928		0	1.17	0.48	0.39	----- z	----- z	----- z	----- z	----- z	1928	----- z	----- z	----- z	2.04 h
1929		----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1929	----- z	----- z	----- z	0 l
1930	1930	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1930	----- z	----- z	----- z	0 l
1931		----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1931	----- z	----- z	----- z	0 l
1932		----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1932	----- z	----- z	----- z	0 l
1933		----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1933	----- z	----- z	----- z	0 l
1934		----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1934	----- z	----- z	----- z	0 l
1935		----- z	----- z	----- z	----- z	----- z	0 n	0.41	1.45	1.33	1935	0.05	0.77	0.52	4.53 f
1936		0.4	0.75	0.47	0.1	0.39	0.05	0.25	1.1	0.44	1936	0.98	0.07 h	1.73 p	4.93 b
1937		0.44	0 e	1.15	0.52	0.7	0.16	2.21	0.59	2.29	1937	0.42	----- z	0.95	9.43 a
1938		0.48	1.41	1.33	0.05	0	----- z	0.21 g	0.22 x	0.31 h	1938	0	0.17	0.83	4.27 d
1939		0.53	0.14	0.41	0.68	0.36	0	0.63	0.72	0.65	1939	0.13	0.53	0.24	5.02
1940	1940	0.8	0.94	0.1	0.86	0.78	0.06	0.86	2.27	2.94	1940	0.82	1.19	3.35	14.97
1941		1.2	1.35 k	1.49 i	2.35	1.83	0.61	2.01	2.86	1.89	1941	2.92	0.6	0.78	17.05 b
1942		0.33	0.78	0.3	1.72	0	0	0.65	1.41	0.49	1942	2.22	0.09	1.65	9.64
1943		2.97	0.1	2.82	0.48	0.31	0.09	0.66	6.2	0.81	1943	0.74 h	0.56	0.68	15.68 a

Totals For Graphing

Canyon De Chelly Total Precipitation

Year	JAS	ANN
1908		
1909	7.44	10.62
1910	3.63	6.83
1911	7.79	13.68
1912	2.93	6.83
1913	2.92	7.95
1914	5.77	9.55
1915	6.55	12.09
1916	3.35	7.12
1917	2.6	5.23
1918	4.96	9.28
1919	2.97	8.18
1920	1.6	7.44
1921	2.83	6.67
1922	3.73	9.42
1923	6.86	13.12
1924	4.9	7.44
1925		
1926		
1927	2.52	8.67
1928		
1929		
1930		
1931		
1932		
1933		
1934		
1935	3.19	4.53
1936	1.79	4.93
1937	5.09	9.43
1938	0.74	4.27
1939	2	5.02
1940	6.07	14.97
1941	6.76	17.05
1942	2.55	9.64
1943	7.67	15.68

Appendix 3.2-B Exhibit 3 Records of Precipitation at Canyon De Chelly

Totals For Graphing

YEAR(S)		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YEAR(S)	OCT	NOV	DEC	ANN			
1944		0.96	0.17	0.97	1.39	1.55	0	0.74	1.37	1.51	1944	0.17	1.22	0.16	10.21	1944	3.62	10.21
1945		0.8	0.36	1.03	0.52	0.06	0.3	1.6	0.82	0.01	1945	0.71	0	0.56	6.77	1945	2.43	6.77
1946		0.11	0.27	0.75	0.48	0.41	0	2.95	1.26	0.81	1946	0.77	1.32	0.24	9.37	1946	5.02	9.37
1947		0.01	0.11	0.17	0.02	1.48	0.27	0.57	2.89	1.97	1947	2.02	0.82	1.18	11.51	1947	5.43	11.51
1948		0.7	1.36	0.57	0.64	0.09	0.75	1.01	1.6	0.99	1948	2.71	0.24	1.38	12.04	1948	3.6	12.04
1949		0.95	0.57	0.48	0.37	0.21	0.87	1.95	0.84	1.03	1949	1	0	0.08	8.35	1949	3.82	8.35
1950	1950	0.08	0.43	0.31	0	0.08	0.43	1.21	0.38	0.34	1950	0	0.18	0.08	3.52	1950	1.93	3.52
1951		0.28	0.11	0.22	0.76	0.8	0	0.9	1.29	0.32	1951	0.95	0.74	0.77	7.14	1951	2.51	7.14
1952		1.42	0.23	0.56	1.42	0.05	0.61	2.18	1.12	1.58	1952	0	1.26	0.33	10.76	1952	4.88	10.76
1953		0.29	0.67	0.34	0.4	0.22	0.09	1.48	2.03	0.07	1953	0.94	0.42	0.07	7.02	1953	3.58	7.02
1954		0.14	0.08	0.91	0.09	0.43	0	1.56	0.44	2.57	1954	0.78	0	0.34	7.34	1954	4.57	7.34
1955		0.44	0.36	0	0.15	0.6	1.08	0.42	1.78	0	1955	0 c	0.24	0.21	5.28	1955	2.2	5.28
1956		1.24	0.23	0.1	0.31	0.54	0.08	0.91	1.11	0	1956	0.7	0.2	0	5.42	1956	2.02	5.42
1957		1.22	0.97	0.74	1.11	2.43	0.13	2.7	1.88	0	1957	1.91	0.59	0.22	13.9	1957	4.58	13.9
1958		0.09	0.56	1.11	0.67	0.35	0.06	0.44	0.82	1.19	1958	0.48	0.49	0.08	6.34	1958	2.45	6.34
1959		0.13	0.6	0	0.84	0	0.14	0.59	2.86	0.28	1959	2.39	0.3	1.09	9.22	1959	3.73	9.22
1960	1960	0.51	0.93	0.15	0.07	0.22	0.37	0.54	0.79	0.15	1960	1.96	0.41	0.85	6.95	1960	1.48	6.95
1961		0.45	0.13	1.75	0.23	0.28	0	1.12	1.28	0.8	1961	1.34	0.64	0.87	8.89	1961	3.2	8.89
1962		0.22	0.39	0.42	0	0.32	0.07	0.15	0.49	1.14	1962	2.05	1.27	0.7	7.22	1962	1.78	7.22
1963		0.95	0.41	0.3	0.07	0.03 a	0.03	1.38	5.19	0.41	1963	0.62	0.81	0.6	10.8	1963	6.98	10.8
1964		0.05	0.05	1.84	1.08	0.09	0.24	1.26	2.38	2.06	1964	0	1.59	0.84	11.48	1964	5.7	11.48
1965		0.92	0.84	0.41	1.12	1.25	1.02	1.96	1.36	1.87	1965	0.94	0.82	1.59	14.1	1965	5.19	14.1
1966		0.23	0.91	0.1	0.15	0	0	2.47	0.64	0.91	1966	0.97	0.41	0.82	7.61	1966	4.02	7.61
1967		0.13	0	0.46	0.16	0.8	0.56	2.34	0.99	0.4	1967	0	0.39	1.86	8.09	1967	3.73	8.09
1968		0.03	0.5	0.47	0.33	0.27	0.28	1.23 w	2.2	0.04	1968	1.35	1.25	0.76	7.48 a	1968	3.47	7.48
1969		0.47	0.53	0.8	0.13	0.7	0.36	1.09	0.6	----- z	1969	----- z	----- z	----- z	4.68 d	1969		
1970	1970	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	----- z	1970	----- z	----- z	0.35	0.35 k	1970		
1971		----- z	0.31	0.07	0.12	0.29	0	0.36	1.72	1.27	1971	1.37	0.38	0.6	6.49 a	1971	3.35	6.49
1972		0.04	0	0	0.02	0.05	0.84	0.71	0.93	0.54	1972	4.45	0.85	1.18	9.61	1972	2.18	9.61
1973		1.24	0.96	2.13	0.37	0.93	0.31	0.35	0.98	0.77	1973	0.02	0.27	0.26	8.59	1973	2.1	8.59
1974		1.04	0.05	0.27	0.01	0	0.08	1.78	0.61	0.96	1974	2.59	0.31	0.27	7.97	1974	3.35	7.97
1975		0.11	0.22	0.98	0.2	0.5	0	0.54	0.31	1.07	1975	0.27	0.45	0.42	5.07	1975	1.92	5.07
1976		0.01	0.29	0.06	0.21	1.89	0.02	0.87	0.49	1.42	1976	0.45	0.25	0	5.96	1976	2.78	5.96
1977		0.35	0.34	0.08	0.03	0.3	0.21	1.45	2.96	0.59	1977	0.43	0.65	0.36	7.75	1977	5	7.75
1978		1.19	0.82	1.2	0.26	1.69	0	0.19	0.5	0.61	1978	1.12	2.2	0.9	10.68	1978	1.3	10.68
1979		1.39	0.52	1.19	0.17	1.37	0.09	0.36	0.42	0.05	1979	1.55	0.72	1.1	8.93	1979	0.83	8.93
1980	1980	1.67	1.87	0.76	1.62	0.28	0	0.38	2.01	0.44	1980	0.85	0.04	0.01	9.93	1980	2.83	9.93
1981		0.2	0.26	1.12	0.09	0.36	0.4	3.2	0.61	0.29	1981	1.29	1.17	0.17	9.16	1981	4.1	9.16
1982		1.16	1.65	1.15	0.67	1.24	0.02	1.16 a	4.84	1.52	1982	0.15	1.3 b	2.74	17.6	1982	7.52	17.6

Appendix 3.2-B Exhibit 3 Records of Precipitation at Canyon De Chelly

YEAR(S)		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YEAR(S)	OCT	NOV	DEC	ANN
1983		0.57 a	1.95	1.22	0.27	0.64	0.44	3.2	0.47	1.46	1983	0.54	0.56	0.9	12.22
1984		0.01	0	1.21	0.66	0.1	0.32	1.6	1.41	1.42	1984	1.5 a	0.43	1.91	10.57
1985		0.92 c	0.09 b	1.51	2.58	0.25	0.02	1.07	0.68	0.95 a	1985	1.4	2.23	0.11	11.81
1986		0	0.68	0.64	0.43 b	0.2	0.34	0.68	0.62	1.57	1986	0.64	1.73	0.61	8.14
1987		0.83	0.89	0.41	0.83	0.88	0.34	1.53	0.77	0.43	1987	1.61	2.16	0.7	11.38
1988		0.35	1.69	0.1	2.93	0.56	2.05	3.38	2	0.36	1988	0.13	1.25	0.23	15.03
1989		0.44	0.92	0.19	0	0	0	0	0.86	0.01	1989	0.82	0	0.05	3.29
1990	1990	0.52	0.55	0.24	0.24	0.5	0.04	2.4	1.26	2.22	1990	0.89	0.56 a	1.22 b	10.64
1991		0.2 b	0	0.61	0.12	0	1.48	0.3	0.67	0.79	1991	0.46	1.98	2.2	8.81
1992		0.51	1.07	1.15	0.06	2.43	0.12	1.05	2.73	0.49	1992	0.56	0.02	1.24 l	10.19 a
1993		----- z	0.98	0.72	0.14	0.18	0	0	----- z	0.04	1993	0.56 a	----- z	0	2.62 c
1994		0	0.59	0.33 a	0.75 a	0.6	0.07	0.34	1.64	1.81	1994	0.66	0.56 a	0.96 a	8.31
1995		2.48 b	0.14	0.81	0.44	0	0.07	0.18	----- z	2.01	1995	0	0.45	0.36 o	6.58 b
1996		0.06 f	1.56	0.06	0.03	0.23	0.16	0.48	0.45	1.46	1996	0.95	0.63	0.06	6.07 a
1997		1.27	0.37	0	2.37	0.69	1.39	0.69	2.48	1.6	1997	1.68	0.76	0.57	13.87
1998		0.46	1.35	0.28 g	0.63	0	0	0.8	0.5	0.57	1998	2.57	0.99	0.36	8.23 a
1999		0.02	0.14	0	0.66	0.8	0.97	2.61	3.35	0.56	1999	0	0	0	9.11
2000	2000	0.28	0.35	2.73	0.35	0.06	0.1	0.6	1.21	0.4	2000	2.26	0.82	0.2	9.36
2001		0.85	0.47	0.46	0.41	0.55	0.23	0.98	1.31	0.09	2001	0.01	0.31	0.89 a	6.56
2002		0.1	0	0	0.31	0	0	1.12	0.87	1.41	2002	0.5	0.58	0.58	5.47
2003		0.13	1.25	0.74	0.01	0	0	0.67	0.66	0.78	2003	0.83	0.5	1.57	7.14
2004		0.37	0.57	0.21	1.24	0	0.44	0.04	0.26	2.66	2004	1	1.11	0.82 a	8.72
2005		1.3	2.62	0.34	1.15	0.48	0.28	0.49	1.3 b	0.55	2005	0.74	0.05	0.05	9.35
2006		0.37	0	0.58	0.08	0	0.1	2.07	1.63	0.36	2006	1.89	0.27	0.38	7.73
2007		0.66	0.86	0.72	0.38	0.56	0	1.21	2.37	0.63	2007	0.14	0.26	1.64	9.43
2008		1.99	1.13	0	0.15	0.29	0.32	2.11	1.07	0.51	2008	0.41	0.71	1.67	10.36
2009		0.46 b	0.8	0.81	0.19	0.84	0.06	1.12	0	0.49	2009	0.31	0.23	0.71	6.02
2010	2010	2.45	0.87	1.19	0.48	0.44	0.1	1.69	1.72	0.88	2010	1.38	0.08	0.83	12.11
2011		0.12	1.03 a	0.68	0.36	0.84	0.03	1.54	0.43	1.18	2011	1.55	0.75	0.69	9.2
2012		0.17	0.15 b	0.35	0.12	0	0.29	1.65	0.37 d	0 b	2012	0.07	0.07	0.68	3.92
2013		0.82	0.17	0.36	0.38	0.12	0.15	1.22	1.86	1.25	2013	0.32	1.35	0.5	8.5
2014		0	0.2	1.14	0.18	0.23	0	1.75	0.89	1.06	2014	0.09	0.15	1.3 o	5.69 a

Totals For Graphing

1983	5.13	12.22
1984	4.43	10.57
1985	2.7	11.81
1986	2.87	8.14
1987	2.73	11.38
1988	5.74	15.03
1989	0.87	3.29
1990	5.88	10.64
1991	1.76	8.81
1992	4.27	10.19
1993		
1994	3.79	8.31
1995		
1996	2.39	6.07
1997	4.77	13.87
1998	1.87	8.23
1999	6.52	9.11
2000	2.21	9.36
2001	2.38	6.56
2002	3.4	5.47
2003	2.11	7.14
2004	2.96	8.72
2005	2.34	9.35
2006	4.06	7.73
2007	4.21	9.43
2008	3.69	10.36
2009	1.61	6.02
2010	4.29	12.11
2011	3.15	9.2
2012	2.02	3.92
2013	4.33	8.5
2014	3.7	5.69
	-0.01105	-0.00155

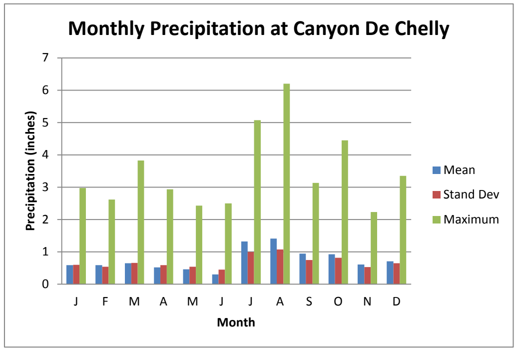
Correlation Coeff: 0.711967

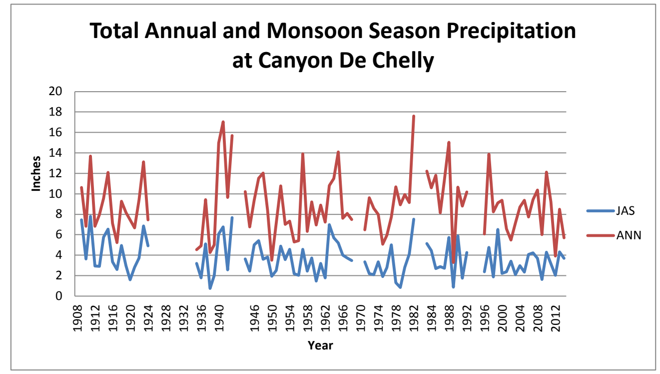
Appendix 3.2-B Exhibit 3 Records of Precipitation at Canyon De Chelly

Totals For Graphing

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
MEAN	0.59	0.59	0.65	0.52	0.46	0.3	1.32	1.41	0.95	0.93	0.61	0.71	9
S.D.	0.6	0.54	0.66	0.59	0.54	0.45	0.99	1.07	0.75	0.82	0.53	0.65	2.79
SKEW	1.65	1.19	2.04	2.01	1.73	2.49	1.26	1.95	0.82	1.26	1.16	1.44	0.5
MAX	2.97	2.62	3.82	2.93	2.43	2.5	5.07	6.2	3.13	4.45	2.23	3.35	17.6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	3.29
YRS	93	95	94	96	95	94	94	93	94	95	93	94	79

Monthly Precip Data for Graphing	Mean	STDev	Max
J	0.59	0.6	2.97
F	0.59	0.54	2.62
M	0.65	0.66	3.82
A	0.52	0.59	2.93
M	0.46	0.54	2.43
J	0.3	0.45	2.5
J	1.32	0.99	5.07
A	1.41	1.07	6.2
S	0.95	0.75	3.13
O	0.93	0.82	4.45
N	0.61	0.53	2.23
D	0.71	0.65	3.35





Appendix 3.2-C

Greenhouse Gas Emissions Data

This page intentionally left blank

Appendix 3.2-C Exhibit 1
Greenhouse Gas Emissions from Proposed Action NGS Operation

NGS Operation

Calculate GHG emissions from Coal based on 40 CFR 98 Tables C-1 and C-2, and the Global Warming Potential for each gas

GHG Component	40 CFR 98 kg/MMBtu	GWP factor	kg CO2e / MMBtu	lb CO2e / MMBtu
CO2	93.28	1	93.28	205.6824
Methane	0.011	25	0.275	0.606375
N2O	0.0016	298	0.4768	1.051344
CO2e		94.0318	**94.0318**	**207.340119**

Convert to MMBtu/MW-hour using heat rate data provided by SRP.

Gross Heat Rate	11194 Btu/kwh	Provided by SRP
	11.194 MMBtu/MWhr	

Conversion	11.194 MMBtu/MWhr	11.194 MMBtu/MWhr	11.194 MMBtu/MWhr
times	207.340119 lb CO2e/ MMBtu	93.28 kg CO2/MMBtu	94.0318 kg CO2e/MMBtu
divided by	2000 lb/Ton	1000 kg/Mg	1000 kg/Mg
	1.160482646 Ton CO2e / MW hour	**1.04417632 Mg CO2/MWhour**	**1.052591969 Mg CO2e/MWhour**

Hours per year Assumed 8,760

NGS Operation	**Units**	**3-Unit Operation**	**2-Unit Operation**	
Power Production	Annual Average MW	1,980	1,320	Calculated at 88 percent capacity factor
Total CO2e	Metric tonnes/year	18,256,997	12,171,331	
	Rounded	18,257,000	12,171,000	
Total CO2	Metric tonnes/year	18,111,029	12,074,020	
	Rounded	18,111,000	12,074,000	
Total CO2e	Short tons/year	20,128,339	13,418,893	
	Rounded	20,128,000	13,419,000	

Appendix 3.2-C Exhibit 2
Greenhouse Gas Emissions from Proposed Action KMC Operation

KMC Operation			
	Calclulate GHG emissions from Sulfur Emissions provided in KMC Modeling Report		
	Emissions from Equipment exhaust		
Assume:	ppm sulfur in diesel	15	
	diesel fuel lb/gal	7.05	
	MMBtu/gallon	0.138	
	kg CO2/MMBtu	73.96	data from 40 CFR 98 table C-1
	kg CH4/MMBtu	0.003	data from 40 CFR 98 table C-2
	kg N2O/MMBtu	0.0006	data from 40 CFR 98 table C-2
	kg CO2e/MMBtu	74.212	Sum multiplied by GWP
	lb CO2e/MMBtu	163.63746	Convert to lbs.

KMC Production (ton/year)	Exhaust SO2 Emissions (ton/year)	Reference table KMC Report	gallons/yr	MMBtu/year	CO2e Mg/year	CO2 Mg/yr	CO2e (ton/year)
8,100,000	0.83	D3	5,400,000	745,200	55,303	55,115	60,971.3
5,500,000	0.54	D1	4,200,000	579,600	43,013	42,867	47,422.1
Incremental GHG per ton of coal production					0.004726734	0.004711	0.005211

KMC Coal from Methane						
Methane Emission	0.17	lb/ton derived from Kichgesser et al.		See below		
	25	methane global warming potential				
8,100,000	688.5	tons of methane	17,213	tons of CO2e	15,615	tonne CO2e
5,500,000	467.5	tons of methane	11687.5	tons of CO2e	10,603	tonne CO2e

NGS Operation	KMC Total Coal Production (ton/year)	Methane Emissions CO2e	Equipment Emissions CO2e	Total Emissions CO2e	Emissions CO2
		Data in Metric Ton per Year			
3-Unit Operation	8,100,000	15,600	55,300	70,900	55,100
2-Unit Operation	5,500,000	10,600	43,000	53,600	42,900

Calculation Backup: **Methane Emissions and CO2e from KMC Coal mining.**

data from Kirchgessner et al (2000)		Coal Production 10^6 ton/year	Methane emissions Ton/year			location	
	Mine						
	A	14	1,354	3,089,429	0.000438	Powder	River
	B	16.8	1,253	3,389,056	0.00037	Powder	River
	C	9.9	786	1,911,686	0.000411	Powder	River
	D	15.3	1,369	3,203,366	0.000427	Powder	River
	E	1.2	43	129,168	0.000333	Northern	App.
	F	0.24	5	21,500	0.000241	Northern	App.
Total	PRB data	56	4,762				
	Avg PRB	methane	0.170071429	lb/ton			
	KMC	Production (ton/yr)			25	GWP	
	KMC	8,100,000	688.7892857	tons methane	17,220	tons/year of CO2e	
		5,500,000	467.6964286	tons methane	11,692	tons/year of CO2e	
		8,100,000			15,619	Mg/year of CO2e	
		5,500,000			10,605	Mg/year of CO2e	

Appendix 3-2-C Exhibit 3
Grenhouse Gas Emissions from Transmission Line and Communication Site Maintenance

The following data estimate emissions for maintenance vehicle travel to the sites. Total maintenance CO2 is estimated based on mileage and diesel fuel factors, as noted below. Emission factors are taken from 40 CFR Part 98 Table C-1 and C-2.

Emissions from Generator routine maintenance are also based on typical generator design and operation including one test each month any typical fuel use. Emissions are based on propane GHG emission factors in 40 CFR Part 98 Tables C-1 and C-2.

Transmission Line Maintenance		
Western Transmission Line	257	miles
	8	Communication Sites
Southern Transmission Line	275	miles
	8	Communication Sites
Annual Maintenance	532	T line distance
	3000	miles access
	3532	total miles
Vehicle mileage	10	miles/gallon diesel
	353.2	total gallons
	73.25	kg/MMBtu
	0.137	MMBtu/gallon
Total CO2	3544.45	kg
	3.54445	Tonnes CO2
Total MMBtu	48.3884	
Methane	0.003	kg/MMBtu
N2O	0.0006	kg/MMBtu
CO2e Weight Methane	25	
CO2e Weight N2O	295	
Total CO2e	3.56	
Generator maintenance	22	kw Estimate
	3.68	gallons/Hour (Generac Guardian, Model 6552)
	0.0905	Mmbtu/gallon
CO2 Emission from Propane	62.87	kg/MMBtu
Total CO2 from 1-hour testing	20.93822	kg CO2 per hour
Assume testing monthly	12	per year
	16	sites
	1	hour per test
	0.33304	MMBtu/hour
	192	hours testing
Methane and N2O	0.003485	tonne Co2e
Total CO2 from Generator maint	4.02	Tonnes CO2
Total CO2e	7.58	tonnes CO2e.

This page intentionally left blank

Appendix 3.2-D

GHG Emissions from PFR Alternatives

This page intentionally left blank

Appendix 3.2-D GHG Emissions from PFR Alternativesl

The following table provides the PFR Alternatives, and the expected target generation levels for each of the considered Alterantives
This table forms the basis for assigning the generation level and hence the GHG emissions for NGS and KMC, based on pro-rated GHG emission data.

PFA	NGS Gen (MW)	Replace-ment	Fraction of Replacement target	Firming power = 10% of Replacement	Generated by Target (MW)	Generated by non-NGS	Total Gen	Fraction of NGS Replaced Power
3-U Proposed	**1980**	**0**				**0.0**	**1980.0**	**0.0000**
2-U Proposed	**1320**	**0**				**0.0**	**1320.0**	**0.0000**
3-U Natural Gas	**1880**	100	1.000	0.0	100.0	**100.0**	**1980.0**	0.9495
3-U Natural Gas	**1730**	250	1.000	0.0	250.0	**250.0**	**1980.0**	0.8737
3-U Renewable	**1921.7**	100	0.583	5.8	52.5	**58.3**	**1980.0**	0.9706
3-U Renewable	**1834.3**	250	0.583	14.6	131.2	**145.8**	**1980.0**	0.9264
3-U Tribal	**1942**	100	0.413	4.1	37.2	**41.3**	**1983.3**	0.9808
3-U Tribal	**1885.1**	250	0.413	10.3	92.9	**103.3**	**1988.4**	0.9521
2-U Natural Gas	**1220**	100	1.000	0.0	100.0	**100.0**	**1320.0**	0.9242
2-U Natural Gas	**1070**	250	1.000	0.0	250.0	**250.0**	**1320.0**	0.8106
2-U Renewable	**1261.7**	100	0.583	5.8	52.5	**58.3**	**1320.0**	0.9558
2-U Renewable	**1174.25**	250	0.583	14.6	131.2	**145.8**	**1320.0**	0.8896
2-U Tribal	**1282.0**	100	0.413	4.130	37.2	**41.3**	**1323.3**	0.9712
2-U Tribal	**1225.1**	250	0.413	10.3	92.9	**103.3**	**1328.4**	0.9281

1.160482646 Ton CO_2e /MWh 1.0441763 Mg CO_2/MWhc 1.052591969 Mg CO_2e/MWhour factors From Appendix 3.2-C Exhibit 1.
Calculations based on 8760 hours per year

Comparison of Emissions from 3-Unit Operation and 3-Unit Partial Replacement Alternatives

Data in metric tons/year

Assessment Topic	Pollutant	Baseline through 2019	3-Unit	Natural Gas PR		Renewable PR		Tribal PR	
				3u-100	3U-250	3u-100	3U-250	3U-100	3U-250
	NGS Power Production		1980	1880	1730	1921.7	1834.3	1942	1885.1
	Ratio			0.9495	0.8737	0.9706	0.9264	0.9808	0.9521
	GHG	Factor T/MWh							
	CO2e NGS (Mg)	1.05259	18,257,000	17,335,000	15,952,000	17,719,000	16,913,000	17,907,000	17,382,000
	CO2 NGS (Mg)	1.04418	18,111,000	17,196,000	15,824,000	17,578,000	16,778,000	17,763,000	17,243,000
	CO2e NGS (tons)	1.16048	20,128,000	19,112,000	17,587,000	19,536,000	18,647,000	19,742,000	19,164,000

Comparison of Emissions from 2-Unit Operation and 2-Unit Partial Replacement Alternatives

Data in metric tons/year

Assessment Topic	Pollutant	Baseline through 2019	3-Unit	Natural Gas PR		Renewable PR		Tribal PR	
				3u-100	3U-250	3u-100	3U-250	3U-100	3U-250
	NGS Power Production		1320	1220	1070	1261.7	1174.3	1282.0	1225.1
	Ratio			0.9242	0.8106	0.9558	0.8896	0.9712	0.9281
	GHG	Factor T/MWh							
	CO2e NGS (Mg)	1.05259	18,257,000	11,249,000	9,866,000	11,634,000	10,827,000	11,821,000	11,296,000
	CO2 NGS (Mg)	1.04418	18,111,000	11,159,000	9,787,000	11,541,000	10,741,000	11,726,000	11,206,000
	CO2e NGS (tons)	1.16048	20,128,000	12,402,000	10,877,000	12,826,000	11,937,000	13,033,000	12,454,000

Emissions from Natural Gas Generation (3-Unit and 2-Unit)

Power Generation	(MW average per year)	100	250	5.8	14.6	4.1	10.3
	Factor (kg /MW-hour)	(Data in metric ton/year, 8760 hours/year)					
NGCC CO2e (Mg)	451.247	395,292	988,231	23,046	57,614	16,326	40,814
NGCC CO2 (Mg)	450.866	394,959	987,397	23,026	57,565	16,312	40,779

NGS Configuration	KMC Total Coal Production (ton/year)	Methane Emissions CO2e	Equipment Emissions CO2e	Total Emissions CO2e	Emissions CO2
		Data in Metric Ton per Year			
3-Unit Proposed Act	8,100,000	15,600	55,300	70,900	55,100
2-Unit Proposed Act	5,500,000	10,600	43,000	53,600	42,900
Alternative A					
3-Unit 100 MW Repl	7,714,000	14,900	53,500	68,400	53,300
3-Unit 250 MW Repl	7,135,000	13,800	50,700	64,500	50,600
2-Unit 100 MW Repl	5,114,000	9,900	41,200	51,100	41,000
2-Unit 250 MW Repl	4,535,000	8,700	38,500	47,200	38,300
Alternative B					
3-Unit 100 MW Repl	7,875,000	15,200	54,200	69,400	54,100
3-Unit 250 MW Repl	7,537,500	14,500	52,600	67,100	52,500
2-Unit 100 MW Repl	5,275,000	10,200	41,900	52,100	41,800
2-Unit 250 MW Repl	4,937,500	9,500	40,400	49,900	40,200
Alternative C					
3-Unit 100 MW Repl	7,941,000	15,300	54,600	69,900	54,400
3-Unit 250 MW Repl	7,701,000	14,800	53,400	68,200	53,200
2-Unit 100 MW Repl	5,341,000	10,300	42,300	52,600	42,100
2-Unit 250 MW Repl	5,101,000	9,800	41,100	50,900	41,000

Equipment Use GHG Factors from Appendix 3.2-C Exhibit 2			CO2e Mg/year	CO2 Mg/yr	CO2e (ton/year)
Production	8,100,000	Ton/year	55,303	55,115	60,971
	5,500,000	Ton/year	43,013	42,867	47,422.0
Ratio		GHG (ton)/Coal (ton)	0.004726923	0.0047107	0.0052112
Factors	0.17	lb CH4/ton coal			
Global Methane Wa	25				

This page intentionally left blank

Appendix 3.2-E

Emissions from Bowie Power Plant

This page intentionally left blank

Appendix 3.2-E Emissions from Bowie Power Plant

Bowie Power Plant (TSD) 1,070 MW capacity

	Total NGS 1400 MW emissions (ton/yr)	lb/hour for each CC UNIT	lb per 100 MW	Tons per year at 100 MW 8760	2 units total
NOX-SCR	12699	101.3	18.9	83	12,782
NOX+SCR	4233	101.3	18.9	83	4,316
SO2	6047	4.1	0.8	3	6,050
CO	9071	262.3	49.0	215	9,286
PM10	1288	8.5	1.6	7	1,295
PM25.	925	8.5	1.6	7	932
VOC	152	1.6	0.3	1	153

Bowie GHG				
p 33 of TSD, part g.				
turbine	1734.6	MMBtu/hour		
Duct B	420	MMBtu/hour		
Total	2154.6	MMBtu/hour		
CO2	53.06	kg/MMBtu	1	GWP
CH4	0.001	kg/MMBtu	25	GWP
N2O	0.0001	kg/MMBtu	298	GWP
GHG-CO2e	53.1148	kg/MMBtu		
	117.0961	lb/MMBtu		
each CC	995	lb/MW-hour		From TSD
CO2	994.0	lb/MW-hour		
	252,295	lb/hour per 530 MW		
each CC	451.247	kg CO2e/MWhour		
	450.866	kg CO2 / Mwhour		
lb/hr	99,500	100	MW	
ton/year	435,810			

Btu/kW-ho	11194				
MW	750				
CF	0.88				
2-unit	129,582,127	MMBtu/year		194,373,190	MMBTU/year-3 unit
GHG	207.246032	lb/MMBtu			
Total GHG	13,427,691	ton/year	2 unit		
	12,532,511		1400 MW		
	20,141,536		3 unit		1400 MW GI
					12,968,321

Coal GHG	CO2	93.28	kg/MMBtu
	CH4	0.01	kg/MMBtu
	N2O	0.0016	kg/MMBtu
	Total	94.0068	kg/MMBtu
		207.246	lb/MMBtu

EMISSIONS FROM NATURAL GAS PRODUCTION, STORAGE, TRANSPORTATION

This page intentionally left blank

Appendix WR-1

Stream Water Quality Characterizations

This page intentionally left blank

Uses designated for major waterbodies within or near the project footprints (NGS, KMC) are summarized in **Tables WR-1.1** and **WR-1.2** below. Respective tribal water quality criteria for common uses of streams on Black Mesa are summarized in **Tables WR-1.3** and **WR-1.4** below. Additional information and standards for other constituents are presented in the respective NNEPA and HTWRP water quality standards references (HTWRP 2008; NNEPA 2008). In addition to the tribal criteria, OSMRE administers a dissolved iron drainage effluent maximum of 10 milligrams per liter (mg/l) for western alkaline mining, based on 40 CFR 434.81. For livestock watering, other published literature recommends additional criteria for fluoride (2 mg/l); nitrate (400 mg/l); sodium chloride (2,500 mg/l, varies); sulfate (1,000 mg/l); and total dissolved solids (TDS) (3,000 mg/l) (Raisbeck et al. 2008; Sigler and Kleehammer 2013).

Table WR-1.1 Summary of NNEPA Designated Uses for Major Project-area Waterbodies on the Navajo Nation

Surface Water Body	Domestic Water Supply (Dom)	Fish Consumption (FC)	Primary Human Contact (PrHC)	Secondary Human Contact (ScHC)	Agric. Water Supply (AgWS)	Aquatic and Wildlife Habitat (A&WHbt)	Livestock Watering (LW)
Antelope Cr.	✓	✓	✓	✓		✓	✓
Kaibito Cr.	✓	✓	✓	✓		✓	✓
Navajo Cr.	✓	✓	✓	✓		✓	✓
Laguna Cr (perennial)		✓	✓	✓	✓	✓	✓
Laguna Cr (non-perennial)		✓		✓		✓	✓
Chinle Cr./W.		✓	✓	✓	✓	✓	✓
Tyende Cr.		✓		✓		✓	✓
Begashibito W.		✓		✓		✓	✓
Shonto W.		✓		✓		✓	✓
Cow Springs Lake		✓	✓	✓		✓	✓
Moenkopi W.		✓		✓	✓	✓	✓
Dinnebito W.		✓		✓		✓	✓
East Fk Dinnebito W.		✓		✓		✓	✓
Oraibi W.		✓		✓		✓	✓
Polacca W.		✓		✓		✓	✓
Jeddito W.		✓		✓		✓	✓

Source: NNEPA 2008.

Table WR-1.2 Summary of HTWRP Designated Uses for Major Project-Area Waterbodies on the Hopi Reservation

Surface Water Body[1]	Aquatic and Wildlife (Warm Water Habitat) (A&Ww)	Primary Contact Ceremonial (PCC)l	Full Body Contact (FBC)	Partial Body Contact (PBC)	Agric. Irrigation (AgI)	Agric. Livestock Watering (AgL)	Ground-water Recharge (GWR)	Domestic Water Source (DWS)
Moenkopi Wash	✓		✓	✓	✓	✓	✓	
Dinnebito Wash	✓		✓	✓	✓	✓	✓	
Oraibi Wash	✓		✓	✓	✓	✓	✓	
Wepo Wash	✓		✓	✓	✓	✓	✓	
Polacca Wash	✓		✓	✓	✓	✓	✓	
Jeddito Wash	✓		✓	✓	✓	✓	✓	
Pasture Canyon Reservoir[2]	✓		✓	✓	✓			
Bacavi Spring	✓	✓	✓	✓	✓			✓
Hotevilla Spring	✓	✓	✓	✓	✓			✓
Moencopi Spring	✓	✓	✓	✓				✓
Redrock Spr Well	✓	✓	✓	✓		✓		✓
Sand Spr North	✓		✓	✓		✓		✓
Other Springs[3]	✓		✓	✓	✓	✓		

1 Ephemeral tributaries of these streams shall meet A&We, PBC, AgI, AgL, and GWR use designations. A&We (ephemeral aquatic and wildlife habitat) is periodically suitable for support and propagation of animals, plants, or other organisms (excluding salmonids).

2 Uses at Pasture Canyon Reservoir also include Fish Consumption (FC).

3 Other springs, such as the Burro Springs, Polacca Spring, Shonto Spring, the Wepo springs and others, have the beneficial uses indicated, typically with agricultural livestock uses, but some have agricultural irrigation uses instead or in addition.

Source: HTWRP 2010.

Table WR-1.3 Navajo (NNEPA) Water Quality Criteria for Uses on Black Mesa

Constituent[1, 2]	Fish Consumption (FC)	Secondary Human Contact (ScHC	Agricultural Water Supply	Aquatic & Wildlife Habitat (acute)	Aquatic & Wildlife Habitat (chronic)	Livestock Watering (LW)
Aluminum	NCNS	NCNS	5.0 d	0.750	0.087	NCNS
Arsenic	0.080	0.280	2.0	0.340 d	0.150 d	0.20 d
Barium	NCNS	98	NCNS	NCNS	NCNS	NCNS
Boron	NCNS	126	1.0	NCNS	NCNS	5.0 d
Cadmium	0.008	0.470	50	0.0077 d, c	0.00064 d, c	0.05
Chromium (III+VI)	NCNS	NCNS	1.0	NCNS	NCNS	1.0
Chromium III	75	1400	NCNS	1.77 d, c	0.231 d, c	NCNS
Chromium VI	0.15	2.8	NCNS	0.016 d	0.011 d	NCNS
Copper	NCNS	9.33	0.2 d	0.050 d, c	0.029 d, c	0.5 d
Fluoride	NCNS	56	NCNS	NCNS	NCNS	NCNS
Lead	NCNS	0.015	10	0.281 d, c	0.011 d, c	0.1
Mercury	0.00015	0.28	NCNS	0.0024	0.000001	NCNS
Nickel	4.6	18.7	NCNS	1.513 d, c	0.168 d, c	NCNS
Nitrate	NCNS	1493.3	NCNS	NCNS	NCNS	NCNS
pH	NCNS	6.5 – 9.0	4.5 – 9.0	6.5 – 9.0	6.5 – 9.0	6.5 – 9.0
Radium 226+228	NCNS	NCNS	NCNS	NCNS	NCNS	30
Selenium	0.67	4.67	0.020	0.033	0.002	0.05
Silver	8	4.67	NCNS	0.0349 d	NCNS	NCNS
Total Suspend. Solids[3]	NCNS	NCNS	NCNS	80	80	NCNS
Vanadium	NCNS	NCNS	0.10 d	NCNS	NCNS	0.10 d
Zinc	5.1	280	10	0.379 d, c	0.382 d, c	25

[1] All values in mg/l unless otherwise noted: pH in standard units, Radium in picocuries/liter; "d" for dissolved analyses, all others are total recoverable.

[2] NCNS: no current numeric standard. Calculated criteria ("c") are based on a median hardness value of 400 mg/l as $CaCO_3$ for PWCC stream samples from 2010 – 2014.

[3] Total Suspended Solids (TSS) criteria are based on a median value determined from a minimum of four samples collected at least 7 days apart, none collected within 48 hours of a local precipitation event.

Source: NNEPA 2008.

Table WR-1.4 Hopi (HTWRP) Water Quality Criteria for Uses on Black Mesa

Constituent [1, 2]	Warm Water Aquatic & Wildlife Habitat (acute)	Warm Water Aquatic & Wildlife Habitat (chronic)	Ephemeral Aquatic & Wildlife Habitat (acute)	Ephemeral Aquatic & Wildlife Habitat (chronic)	Primary Contact Ceremonial (PCC) [3]	Full Body Contact (FBC)	Partial Body Contact (PBC)	Agric. Irrigation (AgI)	Agric. Livestock Watering (AgLW)
Aluminum	NNS	NNS	NNS	NNS	NNS	NNS	NNS	5 d	5 d
Arsenic	0.340 d	0.150 d	0.440 d	0.230 d	0.01	0.03	0.280	2.0 d	0.20 d
Barium	NNS	NNS	NNS	NNS	2.0	186.7	186.7	NNS	NNS
Boron	NNS	NNS	NNS	NNS	1.4	186.7	186.7	1.0	NNS
Cadmium	0.0077 d, c	0.00064 d, c	0.087 d, c	0.0029 d, c	0.005	0.470	0.470	0.05	0.05
Chloride	230	230	230	230	250	250	NNS	NNS	NNS
Chromium III	1.773 d, c	0.231 d, c	5.95 d, c	0.554 d, c	NNS	1400	1400	NNS	NNS
Chromium VI	0.016 d	0.011 d	0.034 d	0.023 d	0.020	2.8	2.8	NNS	NNS
Chromium (total)	NNS	NNS	NNS	NNS	0.10	NNS	NNS	1.0	1.0
Copper	0.050 d, c	0.029 d, c	0.086 d, c	0.051 d, c	1.3	9.33	9.33	5.0	0.5
Electrical Conductivity	Variable [2]	Variable [2]	Variable [2]	Variable [2]	Variable[2]	Variable[2]	Variable [2]	Variable[2]	Variable[2]
Fluoride	NNS	NNS	NNS	NNS	4.0	56	56	NNS	NNS
Iron	NNS	1.0	NNS	NNS	0.30	NNS	NNS	NNS	NNS
Lead	0.281 d, c	0.011 d, c	0.593 d, c	0.023 d, c	0.015	0.015	0.015	1.0	0.1
Manganese	NNS	NNS	NNS	NNS	0.05	130.7	130.7	10	NNS
Mercury	0.0024 d	0.00001 d	0.0024 d	0.00001 d	0.002	0.28	0.28	NNS	0.01
Nickel	1.513 d, c	0.168 d, c	13.5 d, c	1.49 d, c	0.610	18.7	18.7	NNS	NNS
Nitrate	NNS	NNS	NNS	NNS	10	1493	1493	NNS	NNS
pH	6.0 – 9.0	6.0 – 9.0	6.0 – 9.0	6.0 – 9.0	6.5 – 9.0 [2]	6.5 – 9.0 [2]	6.5 – 9.0 [2]	4.5 – 9.0	6.5 – 9.0
Radium 226+228	NNS	NNS	NNS	NNS	5	5	5	30	30

Table WR-1.4 Hopi (HTWRP) Water Quality Criteria for Uses on Black Mesa

Constituent [1, 2]	Warm Water Aquatic & Wildlife Habitat (acute)	Warm Water Aquatic & Wildlife Habitat (chronic)	Ephemeral Aquatic & Wildlife Habitat (acute)	Ephemeral Aquatic & Wildlife Habitat (chronic)	Primary Contact Ceremonial (PCC) [3]	Full Body Contact (FBC)	Partial Body Contact (PBC)	Agric. Irrigation (AgI)	Agric. Livestock Watering (AgLW)
Selenium	NNS	0.002	0.033	0.002	0.17	4.67	4.67	0.02	0.05
Silver	0.0349 d, c	NNS	0.035	NNS	0.035	4.67	4.67	NNS	NNS
Sulfate	250	250	250	250	250	250	NNS	NNS	NNS
Total Dissolved. Solids	500	500	500	500	500	500	NNS	NNS	NNS
Zinc	0.379 d, c	0.382 d, c	3.60	3.33	7.4	280	280	10	25

1 All values in mg/l unless otherwise noted. Electrical conductivity in µmhos/cm; pH in standard units; radium in picocuries/liter; "d" for dissolved analyses, all others are total recoverable.

2 NNS = no numeric standard. Calculated criteria ("c") are based on an 85th percentile hardness value of 400 mg/l (maximum) as $CaCO_3$ for PWCC stream samples from 2010–2014. Electrical conductivity criteria are less than or equal to a 33 percent increase over naturally-occurring levels. Criteria for pH involving all bodily contacts are that the maximum change due to discharge shall be less than or equal to 0.5 units.

3 Primary contact ceremonial criteria generally reflect domestic water supply and groundwater recharge criteria. On Black Mesa, Wepo Aquifer and D-Aquifer uses include agricultural irrigation (AgI) and agricultural livestock watering (AgL). N-Aquifer uses include domestic water supply (DWS); agricultural irrigation (AgI); and agricultural livestock watering (AgL), but the aquifer is confined (under other bedrock formations) on the mesa, which limits these uses.

Source: HTWRP 2010.

Both HTWRP and NNEPA standards provide for protection of formally-identified “unique waters”, which are those ground or surface waters determined to have exceptional cultural, ecological and/or recreational significance. These conditions may be based on flora, fauna, water quality, aesthetic value, or wilderness characteristics. Maintaining and propagating threatened or endangered species through existing water quality, or supporting critical habitat for such species, also can be characteristic of unique waters. Such waters are not specifically identified in NNEPA standards (NNEPA 2008). Classified unique surface waters on the Hopi Reservation include the Moenkopi Wash watershed from Blue Canyon Springs to the confluence of Begashibito Wash. Classified unique groundwaters on Hopi lands include the N-Aquifer and all areas recharging it. The N-Aquifer is defined for this purpose as the Navajo Sandstone, Kayenta Formation, the Wingate Sandstone, and all springs emanating from these units (HTWRP 2008).

The following water quality standards apply to resources classified as unique waters on Hopi tribal lands. These standards supplement or supersede Hopi water quality standards described and tabulated above.

- pH: no change due to discharge;
- Temperature: no increase due to discharge;
- Dissolved oxygen: no decrease due to discharge; and
- Total dissolved solids: no increase due to discharge.

Appendix WR-1. Surface Water Characteristics, PWCC Leasehold

Surface water resources in the study area are dominated by the downstream portions of Lake Powell with its Colorado and San Juan river arms, and several major drainages on or near Black Mesa. Major channels draining to the Little Colorado River include Moenkopi Wash, Dinnebito Wash, Oraibi Wash, Polacca Wash, and Jeddito Wash (main text, **Figure 3.7-3).** Major drainages form generally parallel alignments on Black Mesa. Other drainages associated with these major streams include Pasture Canyon, Shonto Wash, Begashibito Wash, Coal Mine Wash, and Wepo Wash. Major channels draining to the San Juan River or to Lake Powell include Navajo Canyon, Laguna Creek, and Chinle Creek (**Figure 3.7-3**). In their upper reaches, these channels are ephemeral or discontinuous intermittent reaches. Short intermittent or perennial segments can occur where fed by springs. Perennial or longer-duration intermittent flows occur at lower elevations closer to Tuba City (Moenkopi Wash, Pasture Canyon), Shonto Junction (Begashibito Wash), Kykotsmovi (Oraibi Wash), Kayenta (Laguna Creek), and Dennehotso (Chinle Creek).

This appendix focuses on stream characteristics within the PWCC leasehold. Further information for the regional waterbodies mentioned above is presented in **Appendix WR-8**.

Leasehold Streamflow Quantities

Moenkopi Wash and some of its tributaries are sandy over most of their lengths, and runoff seepage into the channel beds (transmission losses) is comparatively large. This process is not as pronounced along Reed Valley Wash, Yellow Water Canyon, and Dinnebito Wash, due to the greater content of silt and clays in those channel beds (PWCC PAP 1986, v.9, ch.15, pg. 81, and v.10, ch15, attach 11). Transmission losses are verified by water level rises in alluvial wells during storm runoff. These losses generally reduce storm runoff peaks and volumes in a downstream direction on the mesa. These streamflow losses also recharge the alluvial aquifer. Peak flow rates are also reduced across the lease areas by runoff retention in sediment ponds or backwater accumulation at culverts or other road crossings.

Baseflows (low flows not resulting from storms) have been measured at the same stations for the same recent period identified in the table above. On Moenkopi Wash at the southwest edge of the lease area, baseflows are small, ranging from zero (dry) to about 15 gallons per minute (gpm) (about 0.033 cfs). Similar conditions are common at the other three stations, but lower Coal Mine Wash and Red Peak Valley Wash sometimes flow at rates on the order of 10 gpm, and occasionally flow at rates of 100 gpm (0.2 cfs) or more. There is no apparent seasonal pattern of recorded baseflows at most stations; the washes may be dry for extensive periods. However, recent springtime baseflows at red Peak Wash (Site 155) are commonly in the tens of gpm (e.g., 20 to 60 gpm or 0.04 to 0.13 cfs). Early fall baseflows at that site are commonly between five and 20 gpm (0.01 to 0.04 cfs). The larger springtime flows may be influenced by snowmelt.

The USGS monitored streamflows at Coal Mine Wash, and on major washes at downstream locations distant from KMC. Monthly average discharges are indicated in **Appendix WR-1, Table WR-1.5**. Based on other USGS daily data, Coal Mine Wash near its mouth is intermittent. Low discharges (e.g., 45 gpm) are indicated during the winter months, but the site is often dry during late spring through fall.

Leasehold Streamflow Quality

Recent stream water quality data were obtained from PWCC and are summarized in **Tables WR-1.6** through **WR-1.20** here in **Appendix WR-1**. Monitoring locations are depicted in **Figure WR-1.1.** General surface water quality characteristics are depicted in **Figures WR-1.2** and **WR-1.3**, for recent data and long-term data, respectively.

In general, stream water quality data from the near-term period 2010 through 2014 (5 years) indicate that open-channel flows on the coal lease areas have mixed major cation chemistry (calcium, magnesium, and sodium), with sulfate as the dominant anion. Total dissolved solids (TDS) concentrations are fairly high, and generally range from about 2,500 mg/L to about 5,000 mg/L. The greater concentrations occur during baseflow periods, when streamflows consist of low flows from groundwater contributions. TDS concentrations generally decline during rainfall periods, when larger flow rates and overland runoff dilute the dissolved fraction. For example, storm water quality on Dinnebito Wash (**Tables WR-1.15** and **WR-1.16**) reflects calcium-sulfate water chemistry, with generally lower dissolved concentrations as represented by the average and median values for TDS, calcium, magnesium, sodium, and sulfate. In these runoff-only samples from Dinnebito Wash, the major dissolved concentrations are lower than sampled baseflows or mixed-flows elsewhere in the lease areas.

Similar effects from flow sources can be observed in **Tables WR-1.8** and **WR-1.9**, where mixed source flows can be compared to baseflows, respectively, at a site on Coal Mine Wash. The mixed baseflow and runoff-affected flows have an average TDS concentration of about 3,000 mg/L, whereas the baseflow-only TDS concentrations average about 5,400 mg/L. This characteristic is consistent on Moenkopi Wash as well, as indicated by major dissolved constituent averages in **Tables WR-1.11** and **WR-1.12**. In addition, **Tables WR-1.13** and **WR-1.14** indicate a similar shift in major dissolved chemistry between flow sources at a site in the Red Peak Valley Wash drainage. This shift between runoff and baseflow water quality typifies many streams in western arid and semi-arid settings, particularly during low-flow periods where background geologic factors have a large influence on surface water quality characteristics.

Baseflow water quality declines slightly downstream for major constituents along Coal Mine Wash, Between Stations SWQ80R and SW25, TDS concentrations increase somewhat, as do sodium and sulfate. The recent average TDS concentration is about 4,820 mg/L at Station SWQ80R (**Appendix Table WR-1.7**), and about 5,370 mg/L downstream at Station SW25 (**Appendix WR-1, Table WR-1.9**). Most trace metals remain consistent, although boron concentrations decrease downstream. Chloride values decline slightly downstream. For baseflows along Moenkopi Wash, recent data (2010 – 2014) indicate similar water quality between Stations SW2A upstream in the lease area, and Station SW26 on Moenkopi Wash downstream of the lease area (see **Appendix WR-1, Figure WR-1.1** and **Tables WR-1.10** and **WR-1.11**). Baseflow concentrations of TDS, sulfate, sodium, and other constituents indicate little change with distance between these two stations. There are elevated selenium concentrations in baseflows at Station SW2A upstream in the lease area. Baseflow selenium concentrations generally are not detected downstream at Station SW26 on Moenkopi Wash. In addition, lower Moenkopi Wash baseflow quality (Station SW26) is generally better than that in middle Coal Mine Wash (Station SW25). Sulfates, TDS, sodium, magnesium and electrical conductivity are generally lower in Moenkopi Wash baseflows at the downstream lease area boundary. Trace elements such as aluminum, arsenic, boron, cadmium, iron, mercury are at low concentrations or are not detected in downstream Moenkopi Wash baseflows. Red Peak Valley Wash baseflow water quality (**Appendix WR-1, Table WR-1.14**) has somewhat lower concentrations of TDS, sulfates, and other major constituents than either the upper or lower Moenkopi Wash sites (SW2A and SW26, respectively). Baseflow trace element concentrations on Red Peak Valley Wash are consistent with those at lower Moenkopi Wash (Station SW26).

In summary tables that reflect rain or snowmelt runoff mixed with baseflow, stream water quality reflects greater total trace metal concentrations as mentioned earlier. On Moenkopi Wash at Site SW26 at the downstream southwestern edge of the coal lease, **Table WR-1.11** indicates improved water quality compared to Coal Mine Wash (Site SW25, **Table WR-1.8**), with generally lower concentrations of most constituents. In comparison to Red Peak Valley Wash (Site SW155, **Table WR-1.13**), the downstream Moenkopi Wash location typically has slightly greater sulfate, TDS, calcium and magnesium concentrations. Trace element concentrations are generally lower at Moenkopi Wash however, and are particularly lower for aluminum, lead, selenium, and vanadium. Total vanadium concentrations are elevated in mixed flow samples from Red Peak Valley Wash, but are well within applicable water quality criteria. Total vanadium concentrations are lower on Moenkopi Wash.

For recent data (2010-2014), summary tables that reflect rain or snowmelt runoff only (**Tables WR-1.15** and **WR-1.16**) indicate that water quality declines in the downstream direction along Dinnebito Wash over about a mile between Site SW34 and new CG34 (see **Figure WR-1.1**). Except for aluminum and arsenic, typical concentrations of most constituents are markedly higher downstream. Typical recent sulfate, TDS, and sodium values increase over the short reach between SW34 and new CG34, as do cadmium, chromium, copper, lead, mercury, vanadium, and zinc. For example, the recent median TDS value at SW34 is 370 mg/l, compared to 1,365 mg/l downstream at new CG34. Similarly, the recent median sulfate concentration at SW34 is 158 mg/l, compared to 800 mg/l at CG34. Based on medians and arithmetic means, total concentrations of trace elements typically exceed either livestock or wildlife surface water criteria at both sites. However, dissolved concentrations of trace elements rarely exceed standards counterparts either upstream at SW34 or downstream at new CG34.

Long-term data (1985-2005) along Dinnebito Wash are more meaningful, given the greater amount of data and more distinct upstream and downstream station locations (CG78 and new CG34, respectively). **Figure WR-1.1** depicts these monitoring sites, where CG78 is clearly upstream of mining activities. In combined runoff and baseflow water quality conditions, typical concentrations of most constituents of interest either declined downstream past the mining activities, or remained similar to upstream background conditions (**Tables WR-1.19** and **WR-1.20**). For example, the long-term median TDS value at CG78 upstream of mining is 1,239 mg/l (**Table WR-1.19)**, compared to 927 mg/l downstream at new CG34 (**Table WR-1.20)**. Similarly, the long-term median sulfate concentration at CG78 is 786 mg/l, compared to 590 mg/l at CG34. Lead and mercury concentrations increase downstream, but only the total lead analyses have a reasonable amount of detected values (approximately 65 percent detected concentrations). The long-term Dinnebito Wash data indicate a general improvement in stream water quality past the mine area.

The summary tables in **Appendix WR-1** reflect values for constituents above the laboratory detection limits at the time of analysis. The number of samples where constituents are not detected is also indicated in relation to the total number of samples. Presenting the information in this manner preserves information from the sampling effort, and helps address data summarization issues involving detection limits and otherwise substituting manufactured data (Croghan and Egeghy 2003; Helsel 2006; Helsel and Hirsch 2002; USEPA 2009). Constituents that are not detected is a frequent condition in the water quality data, often comprising the majority of results.

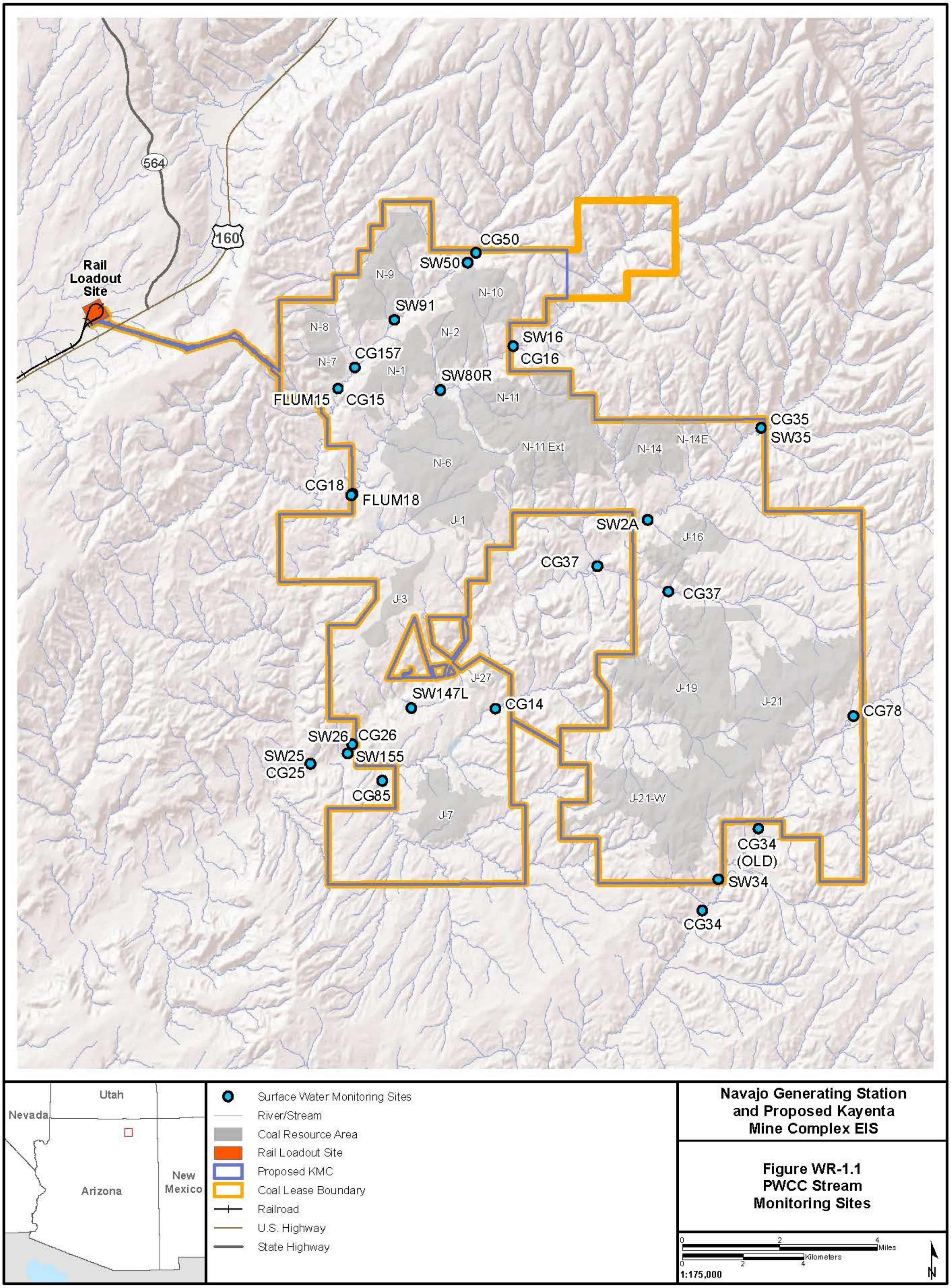
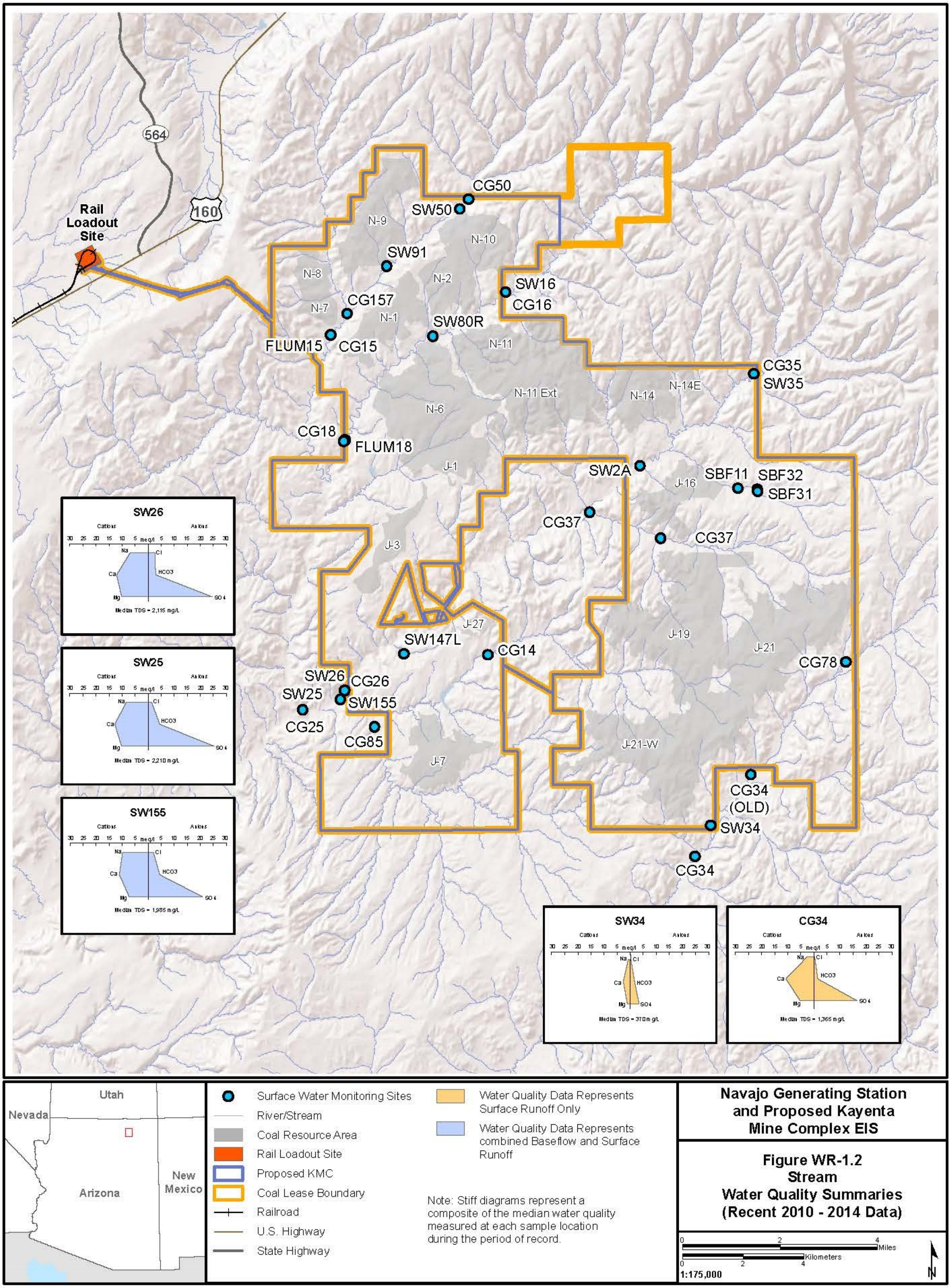


Figure WR-1.1
PWCC Stream
Monitoring Sites

7/20/2016



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-1.2
Stream
Water Quality Summaries
(Recent 2010 - 2014 Data)

X:\0Projects\SRP_NGS_KMC_60299037\FIGs\DOC\EIS\1_PDEIS\Letter_Sized\Water\FIG_WR_1_2_PWCC_StreamMonitoringSites.mxd

7/20/2016

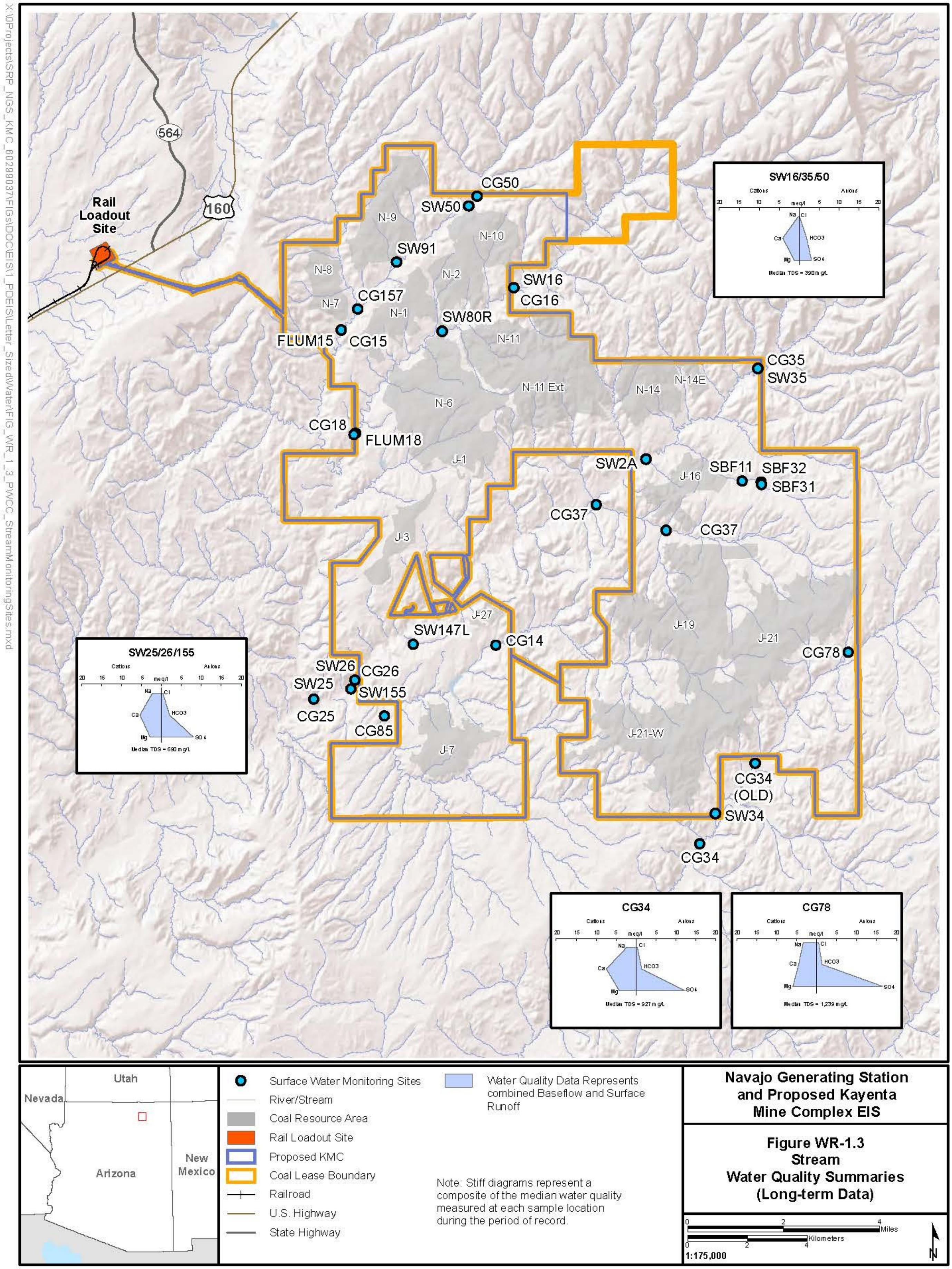


Figure WR-1.3
Stream
Water Quality Summaries
(Long-term Data)

7/20/2016

Table WR-1.5 Monthly Average Flows at USGS Streamflow Gages (cfs)

Location [1]	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coal Mine Wash near mouth (09401239)	Jun 1978 – Sep 1982	1.1	0.46	1.5	0.61	1.0	0.01	0.67	2.0	4.6	1.7	1.2	0.32

1 The USGS gage number is indicated for the location. Flow values are cubic feet per second (cfs).

Source: USGS National Water Information Service (USGS-NWIS) 2016.

This page intentionally left blank

Table WR-1.6 Middle Yellow Water Canyon (Site SW91) Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (Navajo Nation)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife Habitat, chronic	0.087	NCNS	5	1	0.007	0.250	0.086	0.044	0.114	0.0	131.707	0.120	0.22
Aluminum (D)	Agricultural Water Supply	5	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Arsenic, µg/l (T)	Fish Consumption	80	200	5	4	0.60	0.60	0.60	0.60	N/A	N/A	N/A	0.60	0.60
Arsenic, µg/l (D)	Aquatic & Wildlife Habitat, chronic	150	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Bicarbonate	NNS			5	0	288.00	404.00	344.60	337.00	47.38	43.0	13.75	380.00	399.20
Boron, µg/l	Agricultural Water Supply	1,000 (T)	5000 (D)	5	0	260.00	300.00	284.00	290.00	15.17	10.0	5.34	290.00	298.00
Cadmium, µg/l (T)	Fish Consumption	8	50	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Cadmium, µg/l (D)	Aquatic & Wildlife Habitat, chronic	0.64	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			5	0	314.00	367.00	343.20	347.00	21.71	18.0	6.32	359.00	365.40
Chloride	NNS			5	0	38.00	46.00	41.56	41.80	2.96	1.8	7.12	42.00	45.20
Chromium, µg/l (T)	Agricultural Water Supply, Livestock	1000	1000	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	NNS			5	0	3,380.00	3,760.00	3,632.00	3,690.00	158.02	70.0	4.35	3,750.00	3,758.00
Copper, µg/l (T)	Secondary Human Contact	9,330	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife Habitat, chronic	29	500	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	Secondary Human Contact	56,000	NCNS	5	0	0.70	0.81	0.78	0.80	0.05	0.0	5.89	0.80	0.81
Iron (T)	NNS			5	3	0.06	0.20	0.13	0.13	0.10	0.1	76.15	0.17	0.19
Iron (D)	NNS			5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	Secondary Human Contact	15	100	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife Habitat, chronic	11	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			5	0	304.00	384.00	348.20	365.00	37.00	19.0	10.62	375.00	382.20
Manganese (T)	NNS			5	1	0.02	0.03	0.03	0.03	0.01	0.0	23.09	0.03	0.03
Manganese (D)	NNS			5	2	0.01	0.08	0.04	0.04	0.04	0.0	81.79	0.06	0.08
Mercury, µg/l (T)	Aquatic & Wildlife Habitat, chronic	0.001	NCNS)	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Secondary Human Contact	1,493	NCNS	5	0	2.29	5.07	3.45	3.17	1.17	0.9	33.86	4.21	4.90
Nitrite as N	Secondary Human Contact	93.3	NCNS	5	4	0.03	0.03	0.03	0.03	N/A	N/A	N/A	0.03	0.03
$NO_3 + NO_2$	Livestock Watering	132	132	5	0	2.30	5.07	3.47	3.20	1.17	0.9	33.61	4.22	4.90
pH	Livestock Watering	6.5 – 9.0	6.5 – 9.0	5	0	8.20	8.30	8.26	8.30	0.05	0.0	0.66	8.30	8.30
Selenium, µg/l (T)	Aquatic & Wildlife Habitat, chronic	2	50	5	0	2.30	5.00	3.42	3.20	1.00	0.4	29.27	3.60	4.72
Sodium	NNS			5	0	185.00	232.00	214.20	220.00	19.11	12.0	8.92	228.00	231.20
Solids, Dissolved	NNS			5	0	3,470.00	3,830.00	3,662.00	3,670.00	139.71	80.0	3.82	3,750.00	3814.00
Solids, Suspended	Aquatic & Wildlife Habitat	80	NCNS	5	4	9.00	9.00	9.00	9.00	N/A	N/A	N/A	9.00	9.00
Sulfate	NNS		NCNS	5	0	2,180.00	2,400.00	2,288.00	2,300.00	96.54	100.0	4.22	2,360.00	2392.00
Vanadium, µg/l (T)	NNS			5	4	20.00	20.00	20.00	20.00	N/A	N/A	N/A	20.00	20.00
Vanadium, µg/l (D)	Agricultural Water Supply, Livestock	100	100	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Zinc (T)	Fish Consumption	5.1	25	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Zinc (D)	Aquatic & Wildlife Habitat, chronic	0.38	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in standard units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected; N/A = Not Applicable; NCNS = No Current Numeric Standard; NNS = No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.7 Middle Coal Mine Wash (Site SWQ80R) Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (Navajo Nation)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife Habitat, chronic	0.087	NCNS	8	4	0.016	0.700	0.260	0.162	0.322	0.14	123.723	0.400	0.64
Aluminum (D)	Agricultural Water Supply	5	NNS	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Arsenic, µg/l (T)	Fish Consumption	80	200	8	7	3.00	3.00	3.00	3.00	N/A	N/A	N/A	3.00	3.00
Arsenic, µg/l (D)	Aquatic & Wildlife Habitat, chronic	150	NNS	4	3	0.60	0.60	0.60	0.60	N/A	N/A	N/A	0.60	0.60
Bicarbonate	NNS			8	0	536.00	600.00	570.88	576.50	20.72	14.50	3.63	583.50	594.75
Boron, µg/l	Agricultural Water Supply	1,000 (T)	5000 (D)	8	0	170.00	320.00	251.25	260.00	44.86	25.00	17.86	272.50	306.00
Cadmium, µg/l (T)	Fish Consumption	8	50	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Cadmium, µg/l (D)	Aquatic & Wildlife Habitat, chronic	0.64	NNS	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			8	0	417.00	493.00	451.63	453.00	22.97	10.00	5.09	459.75	483.20
Chloride	NNS			8	0	87.00	120.00	104.50	107.00	12.71	12.50	12.16	112.50	120.00
Chromium, µg/l (T)	Agricultural Water Supply, Livestock	1000	1000	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	NNS			8	0	4,400.00	5,060.00	4,733.75	4,725.00	248.94	240.00	5.26	4,960.00	5,035.50
Copper, µg/l (T)	Secondary Human Contact	9,330	NNS	8	7	70.00	70.00	70.00	70.00	N/A	N/A	N/A	70.00	70.00
Copper, µg/l (D)	Aquatic & Wildlife Habitat, chronic	29	500	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	Secondary Human Contact	56,000	NCNS	8	0	0.30	0.40	0.34	0.30	0.05	0.00	15.33	0.40	0.40
Iron (T)	NNS			8	3	0.20	1.10	0.40	0.20	0.39	0.00	98.43	0.30	0.94
Iron (D)	NNS			8	7	0.05	0.05	0.05	0.05	N/A	N/A	N/A	0.05	0.05
Lead, µg/l (T)	Secondary Human Contact	15	100	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife Habitat, chronic	11	NNS	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			8	0	328.00	388.00	361.38	361.50	24.60	24.50	6.81	385.50	387.65
Manganese (T)	NNS			8	0	0.040	0.970	0.519	0.635	0.343	0.25	65.98	0.73	0.91
Manganese (D)	NNS			8	0	0.050	0.928	0.482	0.595	0.316	0.21	65.46	0.67	0.84
Mercury, µg/l (T)	Aquatic & Wildlife Habitat, chronic	0.001	NCNS	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Secondary Human Contact	1,493	NCNS	8	0	0.800	1.920	1.319	1.280	0.323	0.09	24.49	1.38	1.80
Nitrite as N	Secondary Human Contact	93.3	NCNS	8	2	0.020	0.060	0.038	0.035	0.018	0.02	47.87	0.06	0.06
$NO_3 + NO_2$	Livestock Watering	132	132	8	0	0.860	1.940	1.349	1.295	0.313	0.08	23.18	1.42	1.82
pH	Livestock Watering	6.5 – 9.0	6.5 – 9.0	8	0	8.100	8.300	8.175	8.200	0.071	0.05	0.86	8.20	8.27
Selenium, µg/l (T)	Aquatic & Wildlife Habitat, chronic	2	50	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NNS			8	0	394.00	509.00	447.00	439.50	45.19	35.00	10.11	479.75	506.90
Solids, Dissolved	NNS			8	0	4,230.00	5,240.00	4,818.75	4,760.00	348.03	275.00	7.22	5,147.50	5,215.50
Solids, Suspended	Aquatic & Wildlife Habitat	80	NCNS	8	4	6.000	21.000	12.250	11.000	6.500	3.50	53.061	15.000	19.80
Sulfate	NNS		NCNS	8	0	2,300.00	2,800.00	2,611.25	2,650.00	197.52	150.00	7.56	2,800.00	2,800.00
Vanadium, µg/l (T)	NNS			8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Vanadium, µg/l (D)	Agricultural Water Supply, Livestock	100	100	7	6	40.00	40.00	40.00	40.00	N/A	N/A	N/A	40.00	40.00
Zinc (T)	Fish Consumption	5.1	25	8	6	0.070	0.080	0.075	0.075	0.007	0.01	9.428	0.078	0.08
Zinc (D)	Aquatic & Wildlife Habitat, chronic	0.38	NNS	7	6	0.020	0.020	0.020	0.020	N/A	N/A	N/A	0.020	0.02

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in standard units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected; N/A = Not Applicable; NCNS = No Current Numeric Standard; NNS = No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.8 Lower Coal Mine Wash (Site SW25) Runoff and Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (Navajo Nation)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife Habitat, chronic	0.087	NCNS	13	3	0.34	1,650.00	513.98	284.50	597.96	284.14	116.34	956.50	1,429.50
Aluminum (D)	Agricultural Water Supply	5	NNS	13	6	0.04	0.60	0.15	0.08	0.20	0.02	138.27	0.10	0.45
Arsenic, µg/l (T)	Fish Consumption	80	200	13	5	2.30	600.00	228.79	215.00	219.69	191.00	96.02	327.50	554.50
Arsenic, µg/l (D)	Aquatic & Wildlife Habitat, chronic	150	NNS	9	5	0.70	1.30	0.95	0.90	0.25	0.10	26.49	1.00	1.24
Bicarbonate	NNS			13	0	108.00	487.00	272.23	272.00	130.58	122.00	47.97	394.00	431.80
Boron, µg/l	Agricultural Water Supply	1,000 (T)	5,000 (D)	13	0	40.00	360.00	106.92	90.00	81.89	20.00	76.59	110.00	228.00
Cadmium, µg/l (T)	Fish Consumption	8	50	13	10	23.00	90.00	47.00	28.00	37.32	5.00	79.41	59.00	83.80
Cadmium, µg/l (D)	Aquatic & Wildlife Habitat, chronic	0.64	NNS	13	13	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			13	0	34.70	503.00	260.12	254.00	176.41	166.20	67.82	415.00	489.20
Chloride	NNS			13	1	4.00	128.00	52.44	50.50	41.47	36.50	79.08	86.25	108.75
Chromium, µg/l (T)	Agric. Water Supply, Livestock	1,000	1,000	13	7	130.00	1,900.00	988.33	975.00	652.85	525.00	66.06	1,387.50	1,800.00
Chromium, µg/l (D)	NNS			13	13	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	NNS			13	0	394.00	5,790.00	2,960.46	2,430.00	2,149.38	2,036.00	72.60	5,080.00	5,388.00
Copper, µg/l (T)	Secondary Human Contact	9,330	NNS	13	7	110.00	1,900.00	1,158.33	1,285.00	708.16	565.00	61.14	1,717.50	1,875.00
Copper, µg/l (D)	Aquatic & Wildlife Habitat, chronic	29	500	13	10	2.90	4.40	3.80	4.10	0.79	0.30	20.89	4.25	4.37
Fluoride	Secondary Human Contact	56,000	NCNS	13	0	0.30	0.60	0.45	0.41	0.08	0.09	17.60	0.50	0.54
Iron (T)	NNS			13	3	0.30	1,570.00	625.23	392.00	682.83	391.65	109.21	1,331.25	1,529.50
Iron (D)	NNS			13	7	0.03	0.29	0.11	0.08	0.09	0.03	86.48	0.11	0.25
Lead, µg/l (T)	Secondary Human Contact	15	100	13	6	5.50	1,900.00	888.07	895.00	725.67	585.00	81.71	1,420.00	1,774.00
Lead, µg/l (D)	Aquatic & Wildlife Habitat, chronic	11	NNS	13	10	0.20	1.30	0.60	0.30	0.61	0.10	101.38	0.80	1.20
Magnesium	NNS			13	0	7.20	419.00	200.22	123.00	181.22	115.80	90.51	373.00	416.00
Manganese (T)	NNS			13	0	0.32	34.10	10.27	2.33	13.23	1.94	128.82	21.00	32.84
Manganese (D)	NNS			13	0	0.01	2.66	0.41	0.29	0.70	0.22	173.26	0.38	1.38
Mercury, µg/l (T)	Aquatic & Wildlife Habitat, chronic	0.001	NCNS	13	9	3.00	8.00	5.50	5.50	2.08	1.50	37.85	6.50	7.70
Nitrate as N	Secondary Human Contact	1,493	NCNS	13	1	0.03	13.00	1.70	0.76	3.61	0.54	212.28	1.16	7.00
Nitrite as N	Secondary Human Contact	93.3	NCNS	13	5	0.03	0.44	0.13	0.08	0.14	0.04	106.56	0.14	0.37
NO_3 + NO_2	Livestock Watering	132	132	13	0	0.03	12.90	1.63	0.75	3.44	0.54	211.90	1.20	6.47
pH	Livestock Watering	6.5 – 9.0	6.5 – 9.0	13	0	7.80	8.50	8.21	8.20	0.21	0.20	2.56	8.40	8.44
Selenium, µg/l (T)	Aquatic & Wildlife Habitat, chronic	2	50	13	6	2.00	20.00	10.64	10.10	6.69	4.30	62.85	14.75	19.70
Sodium	NNS			13	0	18.40	587.00	283.15	194.00	239.73	175.60	84.67	511.00	576.20
Solids, Dissolved	NNS			13	0	270.00	6,100.00	2,926.15	2,210.00	2,330.25	1,940.00	79.64	5,020.00	5,842.00
Solids, Suspended	Aquatic & Wildlife Habitat	80	NCNS	13	1	7.00	131,000.00	34,294.67	2,640.00	51,379.01	2,632.50	149.82	53,675.00	122,750.00
Sulfate	NNS		NCNS	13	0	17.30	3,600.00	1,640.08	1,220.00	1,396.77	1,202.70	85.16	2,980.00	3,480.00
Vanadium, µg/l (T)	NNS			13	5	20.00	3,560.00	1,426.63	1,315.00	1,342.93	1,183.50	94.13	2,310.00	3,290.50
Vanadium, µg/l (D)	Agric Water Supply, Livestock	100	100	13	10	11.00	28.00	18.00	15.00	8.89	4.00	49.38	21.50	26.70
Zinc (T)	Fish Consumption	5.1	25	13	6	0.03	7.20	3.48	3.61	2.75	2.39	78.86	5.47	6.84
Zinc (D)	Aquatic & Wildlife Habitat, chronic	0.38	NNS	13	12	0.17	0.17	0.17	0.17	N/A	N/A	N/A	0.17	0.17

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected, N/A = Not Applicable; NCNS = No Current Numeric Standard; NNS = No Numeric Standard. Samples are a mix of baseflow and storm water runoff.

Source: PWCC 2012 et seq.

Table WR-1.9 Lower Coal Mine Wash (Site SW25) Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (Navajo Nation)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife Habitat, chronic	0.087	NCNS	5	3	0.34	0.38	0.36	0.36	0.02	0.02	6.68	0.37	0.38
Aluminum (D)	Agricultural Water Supply	5	NNS	5	4	0.04	0.04	0.04	0.04	N/A	N/A	N/A	0.04	0.04
Arsenic, µg/l (T)	Fish Consumption	80	200	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Arsenic, µg/l (D)	Aquatic & Wildlife Habitat, chronic	150	NNS	4	4	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Bicarbonate	NNS			5	0	349.00	395.00	379.60	394.00	21.05	1.00	5.55	394.00	394.80
Boron, µg/l	Agricultural Water Supply	1,000 (T)	5,000 (D)	5	0	90.00	140.00	114.00	110.00	25.10	20.00	22.02	140.00	140.00
Cadmium, µg/l (T)	Fish Consumption	8	50	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Cadmium, µg/l (D)	Aquatic & Wildlife Habitat, chronic	0.64	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			5	0	404.00	503.00	447.60	436.00	42.48	32.00	9.49	480.00	498.40
Chloride	NNS			5	0	67.00	93.00	81.00	85.00	11.81	8.00	14.58	90.00	92.40
Chromium, µg/l (T)	Agricultural Water Supply, Livestock	1,000	1,000	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	NNS			5	0	4,550.00	5,790.00	5,126.00	5,090.00	440.49	30.00	8.59	5,120.00	5,656.00
Copper, µg/l (T)	Secondary Human Contact	9,330	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife Habitat, chronic	29	500	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	Secondary Human Contact	56,000	NCNS	5	0	0.40	0.50	0.48	0.50	0.04	0.00	9.32	0.50	0.50
Iron (T)	NNS			5	3	0.30	0.40	0.35	0.35	0.07	0.05	20.20	0.38	0.40
Iron (D)	NNS			5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	Secondary Human Contact	15	100	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife Habitat, chronic	11	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			5	0	331.00	419.00	386.20	409.00	39.40	10.00	10.20	414.00	418.00
Manganese (T)	NNS			5	0	0.32	0.56	0.45	0.43	0.10	0.11	22.62	0.54	0.56
Manganese (D)	NNS			5	0	0.29	0.53	0.40	0.38	0.11	0.09	27.54	0.51	0.53
Mercury, µg/l (T)	Aquatic & Wildlife Habitat, chronic	0.001	NCNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Secondary Human Contact	1,493	NCNS	5	0	0.03	0.40	0.13	0.06	0.16	0.03	121.21	0.11	0.34
Nitrite as N	Secondary Human Contact	93.3	NCNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
$NO_3 + NO_2$	Livestock Watering	132	132	5	0	0.03	0.40	0.13	0.06	0.16	0.03	121.21	0.11	0.34
pH	Livestock Watering	6.5 – 9.0	6.5 – 9.0	5	0	8.30	8.40	8.36	8.40	0.05	0.00	0.66	8.40	8.40
Selenium, µg/l (T)	Aquatic & Wildlife Habitat, chronic	2	50	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NNS			5	0	446.00	587.00	529.00	532.00	55.20	37.00	10.43	569.00	583.40
Solids, Dissolved	NNS			5	0	4,510.00	6,100.00	5,366.00	5,530.00	614.52	510.00	11.45	5,670.00	6,014.00
Solids, Suspended	Aquatic & Wildlife Habitat	80	NCNS	5	1	7.00	13.00	9.00	8.00	2.71	0.50	30.09	9.25	12.25
Sulfate	NNS		NCNS	5	0	2,610.00	3,600.00	3,118.00	3,000.00	388.23	390.00	12.45	3,400.00	3,560.00
Vanadium, µg/l (T)	NNS			5	4	20.00	20.00	20.00	20.00	N/A	N/A	N/A	20.00	20.00
Vanadium, µg/l (D)	Agricultural Water Supply, Livestock	100	100	5	4	28.00	28.00	28.00	28.00	N/A	N/A	N/A	28.00	28.00
Zinc (T)	Fish Consumption	5.1	25	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Zinc (D)	Aquatic & Wildlife Habitat, chronic	0.38	NNS	5	4	0.17	0.17	0.17	0.17	N/A	N/A	N/A	0.17	0.17

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected; N/A = Not Applicable; NCNS = No Current Numeric Standard; NNS = No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.10 Moenkopi Wash above Reed Valley Wash (Site SW2A) Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (Navajo Nation)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife Habitat, chronic	0.087	NCNS	8	5	0.010	0.025	0.020	0.025	0.009	0.00	43.301	0.025	0.03
Aluminum (D)	Agricultural Water Supply	5	NNS	6	5	0.08	0.08	0.08	0.08	N/A	N/A	N/A	0.08	0.08
Arsenic, µg/l (T)	Fish Consumption	80	200	8	6	0.60	3.00	1.80	1.80	1.70	1.20	94.28	2.40	2.88
Arsenic, µg/l (D)	Aquatic & Wildlife Habitat, chronic	150	NNS	6	5	10.00	10.00	10.00	10.00	N/A	N/A	N/A	10.00	10.00
Bicarbonate	NNS			8	0	173.00	516.00	449.75	496.50	115.18	16.50	25.61	507.75	513.90
Boron, µg/l	Agricultural Water Supply	1,000 (T)	5000 (D)	8	0	270.00	590.00	407.50	390.00	104.03	55.00	25.53	457.50	562.00
Cadmium, µg/l (T)	Fish Consumption	8	50	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Cadmium, µg/l (D)	Aquatic & Wildlife Habitat, chronic	0.64	NNS	8	4	399.00	487.00	439.50	436.00	37.92	25.50	8.63	459.25	481.45
Calcium	NNS			4	0	398.00	487.00	426.63	415.50	30.78	5.50	7.21	442.50	435.35
Chloride	NNS			8	0	160.00	210.00	178.38	178.50	18.62	15.00	10.44	190.00	203.00
Chromium, µg/l (T)	Agricultural Water Supply, Livestock	1000	1000	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	NNS			8	0	4,090.00	5,560.00	4,693.75	4,660.00	440.42	185.00	9.38	4,827.50	5,322.00
Copper, µg/l (T)	Secondary Human Contact	9,330	NNS	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife Habitat, chronic	29	500	7	5	4.00	26.00	15.00	15.00	15.56	11.00	103.71	20.50	24.90
Fluoride	Secondary Human Contact	56,000	NCNS	8	0	0.40	0.80	0.63	0.60	0.16	0.15	25.30	0.80	0.80
Iron (T)	NNS			8	7	0.13	0.13	0.13	0.13	N/A	N/A	N/A	0.13	0.13
Iron (D)	NNS			8	7	0.20	0.20	0.20	0.20	N/A	N/A	N/A	0.20	0.20
Lead, µg/l (T)	Secondary Human Contact	15	100	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife Habitat, chronic	11	NNS	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			8	0	332.00	558.00	442.38	423.50	70.77	45.50	16.00	495.25	536.30
Manganese (T)	NNS			8	0	0.13	1.17	0.51	0.43	0.41	0.30	81.38	0.79	1.05
Manganese (D)	NNS			8	0	0.12	1.11	0.50	0.46	0.40	0.33	80.05	0.78	1.02
Mercury, µg/l (T)	Aquatic & Wildlife Habitat, chronic	0.001	NCNS)	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Secondary Human Contact	1,493	NCNS	8	0	0.17	11.20	7.70	8.11	3.50	1.67	45.42	10.18	10.92
Nitrite as N	Secondary Human Contact	93.3	NCNS	8	1	0.02	0.24	0.11	0.08	0.07	0.03	65.96	0.13	0.21
$NO_3 + NO_2$	Livestock Watering	132	132	8	0	0.17	11.30	7.81	8.22	3.53	1.68	45.25	10.28	11.02
pH	Livestock Watering	6.5 – 9.0	6.5 – 9.0	8	0	8.10	8.50	8.26	8.25	0.14	0.10	1.70	8.33	8.47
Selenium, µg/l (T)	Aquatic & Wildlife Habitat, chronic	2	50	8	4	1.70	3.00	2.18	2.00	0.57	0.15	26.11	2.25	2.85
Sodium	NNS			8	0	321.00	470.00	372.13	363.50	46.09	22.00	12.39	384.50	443.75
Solids, Dissolved	NNS			8	0	4,330.00	5,890.00	4,755.00	4,650.00	518.95	270.00	10.91	4,902.50	5,547.00
Solids, Suspended	Aquatic & Wildlife Habitat	80	NCNS	8	6	6.00	6.00	6.00	6.00	0.00	0.00	0.00	6.00	6.00
Sulfate	NNS		NCNS	8	0	2,300.00	3,600.00	2,680.00	2,600.00	399.00	130.00	14.89	2,650.00	3,320.00
Vanadium, µg/l (T)	NNS			8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Vanadium, µg/l (D)	Agricultural Water Supply, Livestock	100	100	7	6	20.00	20.00	20.00	20.00	N/A	N/A	N/A	20.00	20.00
Zinc (T)	Fish Consumption	5.1	25	8	6	0.06	0.25	0.16	0.16	0.13	0.10	86.68	0.20	0.24
Zinc (D)	Aquatic & Wildlife Habitat, chronic	0.38	NNS	7	6	0.01	0.01	0.01	0.01	N/A	N/A	N/A	0.01	0.01

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected; N/A = Not Applicable; NCNS = No Current Numeric Standard; NNS = No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.11 Lower Moenkopi Wash (Site SW26) Runoff and Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	16	4	0.05	834.00	311.18	312.50	306.14	294.80	98.38	560.50	744.35
Aluminum (D)	Agricultural Water, Livestock (HT)	5	5	14	9	0.04	0.18	0.11	0.09	0.06	0.05	58.00	0.16	0.18
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	16	6	3.80	340.00	135.96	135.00	119.80	98.00	88.11	229.00	293.20
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	12	6	0.60	2.70	1.08	0.80	0.80	0.10	73.71	0.88	2.25
Bicarbonate	NNS			16	0	88.00	474.00	233.69	172.50	147.10	80.50	62.95	373.25	437.25
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	16	0	30.00	130.00	90.63	85.00	31.08	25.00	34.30	120.00	130.00
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	16	11	0.40	40.00	18.88	17.00	14.11	3.00	74.71	20.00	36.00
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	16	16	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			16	0	31.00	518.00	262.33	243.50	197.51	190.35	75.29	463.75	518.00
Chloride	Aquatic & Wildlife (HT)	230	NCNS	16	2	10.00	110.00	68.79	82.50	38.20	19.00	55.54	98.00	110.00
Chromium, µg/l (T)	Livestock (both)	1,000	1,000	16	9	140.00	800.00	600.00	760.00	251.73	40.00	41.95	770.00	794.00
Chromium, µg/l (D)	NNS			16	16	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	16	0	391.00	5,060.00	2,419.63	2,370.00	1,781.67	1,813.50	73.63	4,197.50	4,610.00
Copper, µg/l (T)	Livestock (HT)	500	500	16	8	30.00	1,010.00	613.75	655.00	375.23	295.00	61.14	950.00	989.00
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	16	11	1.20	6.60	3.08	2.80	2.20	1.50	71.41	3.50	5.98
Fluoride	Full Body Contact (HT)	56,000	NCNS	16	0	0.40	0.80	0.56	0.50	0.14	0.10	24.75	0.60	0.80
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	16	3	0.20	900.00	356.70	138.00	387.62	137.80	108.67	779.00	883.20
Iron (D)	NNS			16	9	0.03	0.16	0.07	0.04	0.05	0.01	73.26	0.12	0.15
Lead, µg/l (T)	Full Body Contact (HT)	15	100	16	8	7.30	920.00	571.36	672.00	338.63	229.50	59.27	817.50	913.00
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	16	14	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.50	0.50
Magnesium	NNS			16	0	7.50	341.00	150.81	125.20	135.96	111.85	90.16	295.75	336.50
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	16	0	0.27	23.30	6.35	1.59	7.64	1.31	120.29	12.93	17.60
Manganese (D)	NNS			16	0	0.02	1.86	0.43	0.19	0.54	0.17	125.86	0.78	1.38
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	16	10	1.20	4.00	2.60	3.00	1.08	0.50	41.57	3.00	3.75
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	16	3	0.03	2.39	1.16	1.28	0.76	0.37	65.56	1.44	2.19
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	16	6	0.02	0.17	0.08	0.07	0.06	0.05	70.13	0.12	0.17
$NO_3 + NO_2$	Livestock (NN)	0.132	0.132	16	3	0.03	2.47	1.22	1.30	0.80	0.29	65.42	1.56	2.30
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	16	0	8.00	8.30	8.12	8.10	0.08	0.00	1.03	8.10	8.30
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	16	9	1.60	17.00	8.77	8.00	5.45	4.40	62.19	12.20	15.62
Sodium	NNS			16	0	18.10	422.00	185.28	161.00	162.99	141.75	87.97	345.25	419.00
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	16	0	250.00	5,280.00	2,340.63	2,115.00	1,941.20	1,770.00	82.94	4,285.00	4,867.50
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	16	3	6	43,000	15,758	8,090	18,293	8,083.00	116	38,200	42,040
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	16	0	62.00	2,900.00	1,295.63	1,170.50	1,100.63	1,001.50	84.95	2,450.00	2,720.00
Vanadium, µg/l (T)	Livestock (HT)	100	100	16	5	19.00	1,480.00	735.27	850.00	646.99	620.00	87.99	1,410.00	1,475.00
Vanadium, µg/l (D)	Agricultural Water, Livestock (both)	100	100	16	11	9.00	50.00	21.80	16.00	17.08	7.00	78.35	25.00	45.00
Zinc (T)	Agricultural Water Supply (HT)	10	25	16	5	0.04	3.34	1.57	1.69	1.42	1.47	90.56	3.02	3.25
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	16	15	0.07	0.07	0.07	0.07	N/A	N/A	N/A	0.07	0.07

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected; N/A = Not Applicable; HT = Hopi Tribe; NN = Navajo Nation; NCNS = No Current Numeric Standard; NNS = No Numeric Standard. Samples are a mix of baseflow and storm water runoff.

Source: PWCC 2012 et seq.

Table WR-1.12 Lower Moenkopi Wash (Site SW26) Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	6	4	0.05	0.06	0.05	0.05	0.01	0.01	15.71	0.06	0.06
Aluminum (D)	Agricultural Water, Livestock (HT)	5	5	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	4	4	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Bicarbonate	NNS			6	0	354.00	474.00	407.00	414.00	44.43	32.00	10.92	423.25	461.75
Boron, µg/l	Agricultural Water Supply (HT)	1,000 (T)	5,000 (D)	6	0	80.00	130.00	110.00	120.00	20.00	5.00	18.18	120.00	127.50
Cadmium, µg/l (T)	Fish Consumption	8	50	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			6	0	440.00	518.00	485.83	488.50	33.20	28.00	6.83	515.50	518.00
Chloride	Aquatic & Wildlife (HT)	230	NCNS	6	0	92.00	110.00	100.67	99.00	7.76	6.00	7.71	107.50	110.00
Chromium, µg/l (T)	Livestock (both)	1000	1,000	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	6	0	4,160.00	5,060.00	4,416.67	4,320.00	336.49	140.00	7.62	4,442.50	4,910.00
Copper, µg/l (T)	Livestock (HT)	500	500	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	Full Body Contact (HT)	56,000	NCNS	6	0	0.60	0.80	0.70	0.70	0.11	0.10	15.65	0.80	0.80
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	6	3	0.20	0.50	0.30	0.20	0.17	0.00	57.74	0.35	0.47
Iron (D)	NNS			6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	Full Body Contact (HT)	15	100	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			6	0	255.00	341.00	309.00	316.50	31.98	21.50	10.35	331.25	339.50
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	6	0	0.50	1.93	1.03	0.84	0.50	0.19	48.84	1.15	1.76
Manganese (D)	NNS			6	0	0.45	1.86	0.99	0.82	0.49	0.21	49.65	1.12	1.70
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	6	3	0.03	0.04	0.04	0.04	0.01	0.00	15.75	0.04	0.04
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO_3 + NO_2	Livestock (NN)	0.132	0.132	6	3	0.03	0.04	0.04	0.04	0.01	0.00	15.75	0.04	0.04
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	6	0	8.10	8.30	8.18	8.15	0.10	0.05	1.20	8.28	8.30
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NNS			6	0	317.00	422.00	373.50	373.00	42.09	40.00	11.27	408.25	421.00
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	6	0	4,000.00	5,280.00	4,570.00	4,615.00	449.71	275.00	9.84	4,705.00	5,142.50
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	6	3	6	9	7	7	2	1.00	21	8	8.80
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	6	0	2,140.00	2,900.00	2,550.00	2,600.00	256.98	130.00	10.08	2,645.00	2,840.00
Vanadium, µg/l (T)	Livestock (HT)	100	100	6	5	20.00	20.00	20.00	20.00	N/A	N/A	N/A	20.00	20.00
Vanadium, µg/l (D)	Agricultural Water, Livestock (both)	100	100	6	4	25.00	50.00	37.50	37.50	17.68	12.50	47.14	43.75	48.75
Zinc (T)	Agricultural Water Supply (HT)	10	25	6	5	0.06	0.06	0.06	0.06	N/A	N/A	N/A	0.06	0.06
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	6	5	0.07	0.07	0.07	0.07	N/A	N/A	N/A	0.07	0.07

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected; N/A = Not Applicable; HT = Hopi Tribe; NN = Navajo Nation; = NCNS = No Current Numeric Standard; NNS = No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.13 Red Peak Valley Wash (Site SW155) Runoff and Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (Navajo Nation)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife Habitat, chronic	0.087	NCNS	12	4	0.017	2,120.000	745.332	480.500	859.931	446.43	115.376	1,149.750	2,050.00
Aluminum (D)	Agricultural Water Supply	5	NNS	10	5	0.07	0.54	0.19	0.09	0.20	0.02	105.88	0.15	0.46
Arsenic, µg/l (T)	Fish Consumption	80	200	12	4	0.60	460.00	169.33	122.50	166.17	121.20	98.14	270.25	418.00
Arsenic, µg/l (D)	Aquatic & Wildlife Habitat, chronic	150	NNS	8	5	0.80	1.10	0.97	1.00	0.15	0.10	15.80	1.05	1.09
Bicarbonate	NNS			12	0	68.60	404.00	233.55	259.50	129.49	117.00	55.45	343.25	386.95
Boron, µg/l	Agricultural Water Supply	1,000 (T)	5000 (D)	12	0	20.00	130.00	70.00	65.00	35.68	25.00	50.96	92.50	124.50
Cadmium, µg/l (T)	Fish Consumption	8	50	12	9	12.30	60.00	31.43	22.00	25.21	9.70	80.20	41.00	56.20
Cadmium, µg/l (D)	Aquatic & Wildlife Habitat, chronic	0.64	NNS	11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			12	0	18.10	483.00	231.06	225.20	212.72	203.45	92.06	425.75	462.10
Chloride	NNS			12	2	2.00	80.00	43.55	65.00	34.65	11.00	79.56	69.75	76.40
Chromium, µg/l (T)	Agricultural Water Supply, Livestock	1,000	1,000	12	6	140.00	2,680.00	1,175.00	830.00	1,057.20	615.00	89.97	1,935.00	2,580.00
Chromium, µg/l (D)	NNS			11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	NNS			12	0	169.00	4,880.00	2,268.42	2,211.50	2,085.08	1,954.50	91.92	4,150.00	4,627.00
Copper, µg/l (T)	Secondary Human Contact	9,330	NNS	12	6	170.00	2,640.00	1,350.00	1,125.00	1,053.98	820.00	78.07	2,245.00	2,630.00
Copper, µg/l (D)	Aquatic & Wildlife Habitat, chronic	29	500	11	8	1.70	3.70	2.93	3.40	1.08	0.30	36.77	3.55	3.67
Fluoride	Secondary Human Contact	56,000	NCNS	12	0	0.30	0.60	0.48	0.50	0.09	0.04	17.88	0.50	0.60
Iron (T)	NNS			12	6	205.00	2,160.00	1,109.67	981.00	833.25	728.00	75.09	1,790.00	2,127.50
Iron (D)	NNS			12	6	0.06	0.15	0.10	0.09	0.04	0.03	38.52	0.12	0.15
Lead, µg/l (T)	Secondary Human Contact	15	100	12	6	183.00	2,900.00	1,240.92	914.00	1,046.47	605.25	84.33	1,810.75	2,700.00
Lead, µg/l (D)	Aquatic & Wildlife Habitat, chronic	11	NNS	11	8	0.30	0.40	0.37	0.40	0.06	0.00	15.75	0.40	0.40
Magnesium	NNS			12	0	3.60	199.00	93.49	90.30	92.52	86.50	98.96	179.25	192.40
Manganese (T)	NNS			12	2	0.02	45.80	14.15	6.03	17.66	6.01	124.84	22.00	44.05
Manganese (D)	NNS			12	4	0.01	0.07	0.02	0.01	0.02	0.00	109.77	0.02	0.05
Mercury, µg/l (T)	Aquatic & Wildlife Habitat, chronic	0.001	NCNS)	12	6	0.70	7.00	3.67	3.00	2.74	2.00	74.70	6.00	7.00
Nitrate as N	Secondary Human Contact	1,493	NCNS	12	0	0.42	48.70	18.10	13.95	18.61	13.39	102.81	34.38	43.31
Nitrite as N	Secondary Human Contact	93.3	NCNS	12	1	0.02	0.63	0.15	0.08	0.19	0.05	121.51	0.17	0.50
$NO_3 + NO_2$	Livestock Watering	132	132	12	0	0.42	48.80	18.25	14.13	18.65	13.55	102.22	34.58	43.41
pH	Livestock Watering	6.5 – 9.0	6.5 – 9.0	12	0	8.00	8.40	8.20	8.20	0.12	0.10	1.47	8.23	8.40
Selenium, µg/l (T)	Aquatic & Wildlife Habitat, chronic	2	50	12	0	1.80	46.60	23.52	22.65	14.53	13.30	61.80	37.25	42.42
Sodium	NNS			12	0	4.40	567.00	252.64	229.90	255.80	222.10	101.25	469.75	560.95
Solids, Dissolved	NNS			12	0	100.00	4,900.00	2,137.50	1,985.00	2,025.22	1,775.00	94.75	3,877.50	4,504.00
Solids, Suspended	Aquatic & Wildlife Habitat	80	NCNS	12	3	6	105,000	37,980	24,700	43,169	24,693.00	114	53,400	105,000.00
Sulfate	NNS		NCNS	12	0	15.00	2,680.00	1,152.40	992.00	1,173.09	973.00	101.80	2,185.00	2,526.00
Vanadium, µg/l (T)	NNS			12	4	20.00	4,500.00	1,622.50	1,135.00	1,761.09	950.00	108.54	2,370.00	4,321.50
Vanadium, µg/l (D)	Agricultural Water Supply, Livestock	100	100	11	8	10.00	22.00	17.33	20.00	6.43	2.00	37.09	21.00	21.80
Zinc (T)	Fish Consumption	5.1	25	12	6	0.67	10.00	4.53	3.65	3.68	2.63	81.19	6.87	9.47
Zinc (D)	Aquatic & Wildlife Habitat, chronic	0.38	NNS	11	10	0.13	0.13	0.13	0.13	N/A	N/A	N/A	0.13	0.13

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected; N/A = Not Applicable; NCNS = No Current Numeric Standard; NNS = No Numeric Standard. Samples are a mix of baseflow and storm water runoff.

Source: PWCC 2012 et seq.

Table WR-1.14 Red Peak Valley Wash (Site SW155) Baseflow Water Quality Summary, 2010 – 2014[1]

Chemical Constituent	Most Protective Standard (Navajo Nation)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife Habitat, chronic	0.087	NCNS	6	4	0.017	0.136	0.077	0.077	0.084	0.06	109.994	0.106	0.13
Aluminum (D)	Agricultural Water Supply	5	NNS	6	5	0.09	0.09	0.09	0.09	N/A	N/A	N/A	0.09	0.09
Arsenic, µg/l (T)	Fish Consumption	80	200	6	4	0.60	2.00	1.30	1.30	0.99	0.70	76.15	1.65	1.93
Arsenic, µg/l (D)	Aquatic & Wildlife Habitat, chronic	150	NNS	4	4	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Bicarbonate	NNS			6	0	68.60	404.00	233.55	259.50	129.49	86.00	55.45	343.25	396.25
Boron, µg/l	Agricultural Water Supply	1,000 (T)	5000 (D)	6	0	40.00	130.00	95.00	95.00	31.46	15.00	33.12	115.00	127.50
Cadmium, µg/l (T)	Fish Consumption	8	50	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Cadmium, µg/l (D)	Aquatic & Wildlife Habitat, chronic	0.64	NNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			6	0	402.00	483.00	433.67	430.50	29.26	17.00	6.75	443.75	473.50
Chloride	NNS			6	0	63.00	80.00	70.17	69.50	5.71	2.50	8.13	71.50	78.00
Chromium, µg/l (T)	Agric. Water Supply, Livestock	1000	1000	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	NNS			6	0	3,940.00	4,880.00	4,250.00	4,150.00	353.84	200.00	8.33	4,352.50	4,765.00
Copper, µg/l (T)	Secondary Human Contact	9,330	NNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife Habitat, chronic	29	500	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	Secondary Human Contact	56,000	NCNS	6	0	0.30	0.50	0.45	0.50	0.08	0.00	18.59	0.50	0.50
Iron (T)	NNS			6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Iron (D)	NNS			6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	Secondary Human Contact	15	100	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife Habitat, chronic	11	NNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			6	0	172.00	199.00	181.83	179.50	9.91	6.50	5.45	185.25	196.00
Manganese (T)	NNS			6	2	0.02	0.05	0.03	0.03	0.02	0.01	46.15	0.04	0.05
Manganese (D)	NNS			6	3	0.02	0.07	0.04	0.02	0.03	0.00	85.16	0.05	0.07
Mercury, µg/l (T)	Aquatic & Wildlife Habitat, chronic	0.001	NCNS)	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Secondary Human Contact	1,493	NCNS	6	0	26.00	48.70	35.10	34.75	8.26	5.70	23.54	38.05	46.25
Nitrite as N	Secondary Human Contact	93.3	NCNS	6	0	0.03	0.63	0.19	0.11	0.22	0.05	115.98	0.18	0.52
$NO_3 + NO_2$	Livestock Watering	132	132	6	0	26.00	48.80	35.30	34.95	8.19	5.45	23.21	38.18	46.35
pH	Livestock Watering	6.5 – 9.0	6.5 – 9.0	6	0	8.10	8.40	8.25	8.20	0.12	0.05	1.48	8.35	8.40
Selenium, µg/l (T)	Aquatic & Wildlife Habitat, chronic	2	50	6	0	25.30	46.60	35.73	37.50	7.70	5.25	21.56	38.75	44.70
Sodium	NNS			6	0	442.00	567.00	494.83	480.50	56.15	38.00	11.35	542.50	564.25
Solids, Dissolved	NNS			6	0	3,650.00	4,900.00	4,051.67	3,955.00	471.14	255.00	11.63	4,162.50	4,720.00
Solids, Suspended	Aquatic & Wildlife Habitat	80	NCNS	6	3	6.00	7.00	6.67	7.00	0.58	0.00	8.66	7.00	7.00
Sulfate	NNS		NCNS	6	0	1,910.00	2,680.00	2,261.67	2,240.00	271.69	150.00	12.01	2,387.50	2,610.00
Vanadium, µg/l (T)	NNS			6	4	20.00	20.00	20.00	20.00	0.00	0.00	0.00	20.00	20.00
Vanadium, µg/l (D)	Agricultural Water Supply, Livestock	100	100	6	4	20.00	22.00	21.00	21.00	1.41	1.00	6.73	21.50	21.90
Zinc (T)	Fish Consumption	5.1	25	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Zinc (D)	Aquatic & Wildlife Habitat, chronic	0.38	NNS	6	5	0.13	0.13	0.13	0.13	N/A	N/A	N/A	0.13	0.13

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND = Not Detected; N/A = Not Applicable; NCNS = No Current Numeric Standard; NNS = No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.15 Central Dinnebito Wash (Site SW34) Storm Runoff Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	8	0	19.60	2,890.00	1,162.20	974.50	969.61	725.00	83.43	1,692.50	2,578.50
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	7	2	0.04	0.28	0.17	0.18	0.10	0.07	55.96	0.25	0.27
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	8	0	7.70	1,050.00	354.34	340.50	327.46	103.00	92.42	422.50	873.00
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	6	0	0.70	1.40	1.05	1.10	0.26	0.20	24.65	1.18	1.35
Bicarbonate	NNS			8	0	73.00	173.00	101.63	96.50	31.36	11.50	30.86	104.75	149.90
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	8	0	40.00	110.00	62.50	60.00	23.15	15.00	37.03	65.00	99.50
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	8	3	0.40	100.00	32.06	21.00	40.64	18.10	126.76	36.00	87.20
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			8	0	28.20	348.00	103.65	55.55	107.92	25.15	104.12	131.75	276.25
Chloride	Aquatic & Wildlife (HT)	230	NCNS	8	1	4.00	25.00	8.93	6.00	7.54	2.00	84.46	9.25	20.95
Chromium, µg/l (T)	Livestock (both)	1000	1000	8	0	20.00	4,000.00	1,393.75	950.00	1,339.89	840.00	96.14	1,985.00	3,489.00
Chromium, µg/l (D)	NNS			8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	8	0	284.00	3,010.00	906.00	577.00	898.49	267.00	99.17	982.75	2,348.50
Copper, µg/l (T)	Livestock (HT)	500	500	8	0	20.00	4,000.00	1,560.00	1,205.00	1,370.72	1,135.00	87.87	2,472.50	3,541.50
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	8	2	2.40	6.20	4.17	4.05	1.50	1.25	36.01	5.23	6.00
Fluoride	Full Body Contact (HT)	56,000	NCNS	8	0	0.50	0.70	0.63	0.60	0.07	0.05	11.31	0.70	0.70
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	8	0	22.10	4,370.00	1,459.76	990.00	1,422.41	835.50	97.44	1,965.00	3,701.50
Iron (D)	NNS			8	4	0.06	0.14	0.11	0.11	0.03	0.02	32.53	0.13	0.14
Lead, µg/l (T)	Full Body Contact (HT)	15	100	8	0	16.50	4,200.00	1,538.69	1,140.00	1,442.52	775.00	93.75	2,020.00	3,815.00
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	8	5	0.20	0.60	0.37	0.30	0.21	0.10	56.77	0.45	0.57
Magnesium	NNS			8	0	7.00	103.00	26.98	14.10	32.30	7.00	119.74	28.38	79.27
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	8	0	0.31	73.50	28.14	20.70	24.75	18.29	87.93	41.50	65.24
Manganese (D)	NNS			8	2	0.008	0.061	0.022	0.010	0.021	0.00	98.413	0.027	0.05
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	8	2	2.00	11.00	5.67	6.00	3.14	1.50	55.43	6.00	9.75
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	8	0	0.94	3.27	2.15	2.33	0.80	0.59	37.17	2.71	3.09
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	8	1	0.030	0.190	0.100	0.080	0.060	0.04	59.722	0.140	0.18
NO3 + NO2	Livestock (NN)	0.132	0.132	8	0	0.95	3.43	2.24	2.43	0.85	0.65	38.08	2.85	3.24
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	8	0	8.10	8.20	8.11	8.10	0.04	0.00	0.44	8.10	8.17
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	8	2	7.10	39.00	17.17	14.00	11.71	5.85	68.22	19.10	34.33
Sodium	NNS			8	0	10.10	70.10	27.46	18.80	22.99	8.40	83.71	33.03	65.03
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	8	0	252.00	2,120.00	661.50	370.00	632.14	104.00	95.56	760.00	1,686.00
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	8	0	510.00	194,000	70,338	51,350	71,519	39,750	101.68	101,700	180,700
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	8	0	73.70	1,270.00	349.51	158.00	405.06	78.45	115.89	447.00	999.80
Vanadium, µg/l (T)	Livestock (HT)	100	100	8	0	50.00	5,890.00	2,461.25	1,850.00	2,085.02	1,665.00	84.71	3,867.50	5,473.50
Vanadium, µg/l (D)	Agric Water, Livestock (both)	100	100	8	7	16.00	16.00	16.00	16.00	N/A	N/A	N/A	16.00	16.00
Zinc (T)	Agricultural Water Supply (HT)	10	25	8	0	0.09	14.50	5.37	4.02	4.79	3.69	89.16	8.10	12.46
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	8	7	0.02	0.020	0.020	0.020	N/A	N/A	N/A	0.020	0.02

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.16 Lower Dinnebito Wash (Site CG34) Storm Runoff Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	6	0	1.52	2,490.0	859.8	245.7	1,143.3	226.94	132.97	1,713	2,402.50
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	5	3	0.040	0.370	0.205	0.205	0.233	0.17	113.83	0	0.35
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	6	1	1.30	910.0	219.6	11.6	392.2	10.30	178.64	168	761.60
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	4	1	0.800	3.600	1.900	1.300	1.493	0.50	78.60	2	3.37
Bicarbonate	NNS			6	0	66.0	225.0	117.0	94.0	57.9	18.00	49.45	128	203.00
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	6	0	80.00	160.00	111.67	110.00	27.87	15.00	24.96	118	150.00
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	6	3	0.70	184.00	88.23	80.00	91.93	79.30	104.19	132	173.60
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			6	0	53.8	439.0	224.1	215.0	136.2	79.00	60.78	283	401.75
Chloride	Aquatic & Wildlife (HT)	230	NCNS	6	0	6.0	29.0	15.3	13.0	8.2	4.50	53.25	19	26.75
Chromium, µg/l (T)	Livestock (both)	1000	1000	6	1	40.0	5,900.0	2374.0	2,660.0	2,447.1	2,590.00	103.08	3,200	5,360.00
Chromium, µg/l (D)	NNS			6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	6	0	467.0	2,710.0	1,538.7	1,550.0	795.2	542.50	51.68	1,940	2,537.50
Copper, µg/l (T)	Livestock (HT)	500	500	6	1	30.0	11,100.0	3366.0	2,550.0	4,546.3	2,500.00	135.07	3,100	9,500.00
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	6	3	2.400	7.000	4.633	4.500	2.303	2.10	49.70	6	6.75
Fluoride	Full Body Contact (HT)	56,000	NCNS	6	0	0.500	0.900	0.672	0.650	0.158	0.14	23.45	1	0.88
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	6	0	0.8	7,390.0	2,156.9	1,377.0	2,888.5	1,363.27	133.92	2,755	6,235.00
Iron (D)	NNS			6	4	0.030	1.390	0.710	0.710	0.962	0.68	135.45	1	1.32
Lead, µg/l (T)	Full Body Contact (HT)	15	100	6	1	0.7	7,470.0	2,780.3	2,900.0	3,074.5	2,869.10	110.58	3,500	6,676.00
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	6	5	1.40	1.40	1.40	1.40	N/A	N/A	N/A	1	1.40
Magnesium	NNS			6	0	11.2	143.0	67.8	62.5	47.2	32.60	69.69	90	131.35
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	6	0	0.0	166.0	43.7	22.8	64.2	22.65	147.07	49	137.00
Manganese (D)	NNS			6	0	0.013	0.559	0.121	0.031	0.216	0.01	178.38	0	0.44
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	6	3	6.00	20.00	11.67	9.00	7.37	3.00	63.18	15	18.90
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	6	0	1.20	3.63	2.53	2.54	0.84	0.46	33.03	3	3.50
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	6	0	0.08	1.90	0.42	0.14	0.73	0.01	173.60	0	1.46
NO3 + NO2	Livestock (NN)	132	132	6	0	2.25	3.75	2.95	2.98	0.54	0.37	18.23	3	3.62
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	6	0	7.90	8.20	8.02	8.00	0.12	0.10	1.46	8	8.18
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	6	0	3.5	79.3	24.6	12.5	29.5	8.35	119.80	31	68.23
Sodium	NNS			6	0	19.4	105.0	59.1	58.3	35.8	29.05	60.62	85	100.23
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	6	0	390.0	2,760.0	1,465.0	1,365.0	802.2	385.00	54.76	1,768	2,530.00
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	6	0	18.0	332,000.0	104,938.0	62,270.0	133,318.1	61,726.00	127.04	159,750	292,000
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	6	0	157.0	1650.0	801.5	800.0	539.0	359.00	67.25	1,030	1,502.50
Vanadium, µg/l (T)	Livestock (HT)	100	100	6	1	69.0	13,700.0	4,575.8	4,200.0	5,556.8	4,070.00	140.00	10,292	11,916.00
Vanadium, µg/l (D)	Agric Water, Livestock (both)	100	100	6	4	12.00	16.00	14.00	14.00	2.83	2.00	20.20	15	15.80
Zinc (T)	Agricultural Water Supply (HT)	10	25	6	1	0.13	32.90	10.63	7.83	13.46	7.62	126.58	12	28.74
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	6	4	0.02	0.09	0.06	0.06	0.05	0.04	90.00	0	0.09

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.17 Moenkopi Wash Upstream Sites (Locations 16, 35, 50), Long-term Runoff and Baseflow Water Quality Summary [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	67	1	0.7	2800.0	452.2	284.0	492.0	215.8	108.8	637.5	1,252.5
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	54	22	0.1	24.1	2.9	0.8	5.0	0.62	174.1	2.8	10.0
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	67	18	3.0	850.0	115.1	40.0	199.7	28.0	173.5	120.0	666.0
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	54	41	1.0	14.0	3.1	2.0	3.6	1.0	116.8	3.0	9.2
Bicarbonate	NNS			84	0	32.0	1,022.0	143.8	116.0	121.8	32.0	84.7	152.2	295.6
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	82	18	1.0	398.0	75.5	55.0	65.9	25.0	87.3	92.5	208.5
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	67	51	8.0	340.0	65.8	35.5	86.0	22.0	130.8	80.0	227.5
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	58	51	2.0	11.0	6.1	5.0	3.2	3.0	52.7	8.5	10.4
Calcium	NNS			87	0	11.0	580.0	115.3	82.0	114.4	51.6	99.3	148.5	338.9
Chloride	Aquatic & Wildlife (HT)	230	NCNS	87	9	1.0	69.0	11.1	4.5	14.9	2.5	134.0	10.0	45.8
Chromium, µg/l (T)	Livestock (both)	1000	1000	67	13	10.0	1,950.0	434.4	275.0	440.4	185.0	101.4	555.0	1,350.5
Chromium, µg/l (D)	NNS			53	50	10.0	30.0	20.0	20.0	10.0	10.0	50.0	25.0	29.0
Conductivity	<1.5 x background (HT)	NCNS	NCNS	55	0	83.0	3,570.0	482.5	270.0	613.8	145.0	127.2	508.0	1,648.4
Copper, µg/l (T)	Livestock (HT)	500	500	67	7	10.0	3,500.0	627.7	395.0	673.8	290.0	107.3	842.5	1,912.5
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	54	39	10.0	80.0	22.0	20.0	19.3	10.0	87.9	20.0	59.0
Fluoride	Full Body Contact (HT)	56,000	NCNS	87	0	0.1	1.8	0.4	0.3	0.2	0.1	57.3	0.5	0.8
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	83	1	0.1	4,125.0	638.7	342.0	823.2	286.0	128.9	876.8	1,929.3
Iron (D)	NNS			81	14	0.0	6.8	0.4	0.1	1.0	0.1	232.3	0.3	1.8
Lead, µg/l (T)	Full Body Contact (HT)	15	100	67	25	20.0	3,100.0	732.2	540.0	670.4	385.0	91.6	1,150.0	1,842.5
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	53	47	20.0	80.0	33.3	25.0	23.4	5.0	70.1	30.0	67.5
Magnesium	NNS			86	0	0.7	247.0	34.1	15.4	49.3	11.5	144.3	40.0	126.0
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	82	1	0.3	141.0	15.2	9.0	20.9	6.5	137.8	18.0	41.3
Manganese (D)	NNS			81	26	0.01	8.10	0.96	0.06	1.93	0.05	202.09	0.84	5.38
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	25	16	1.00	2.00	1.33	1.00	0.50	0	37.50	2.00	2.00
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	87	5	0.01	7.50	1.14	0.90	1.19	0.50	103.75	1.40	2.49
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	82	28	0.01	1.00	0.08	0.04	0.14	0.02	181.84	0.08	0.18
NO3 + NO2	Livestock (NN)	0.132	0.132	44	1	0.22	8.50	1.43	1.10	1.49	0.65	104.02	1.88	2.56
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	80	0	6.40	8.30	7.45	7.40	0.36	0.20	4.87	7.70	8.00
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	67	43	1.00	40.00	10.63	6.50	10.01	4.00	94.19	19.25	24.70
Sodium	NNS			86	2	1.00	300.00	18.20	5.65	38.70	3.95	212.59	12.40	84.55
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	87	0	60.0	3,580.0	655.1	390.0	716.7	248.0	109.4	814.0	2,292.6
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	78	1	52.0	325,500.0	37,682.5	17,200.0	57,241.8	14,990.0	151.9	48,230.0	101,190.0
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	87	3	3.0	2,159.0	340.4	150.0	467.3	128.0	137.3	392.8	1,380.2
Vanadium, µg/l (T)	Livestock (HT)	100	100	67	5	10.0	3,100.0	878.1	615.0	804.3	415.0	91.6	1,275.0	2,593.5
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	54	45	10.0	230.0	61.1	30.0	71.1	10.0	116.4	90.0	178.0
Zinc (T)	Agricultural Water Supply (HT)	10	25	67	1	0.1	7.9	2.0	1.3	1.9	0.9	95.1	2.9	5.9
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	54	23	0.0	0.2	0.1	0.0	0.1	0.02	98.5	0.1	0.2

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.18 Moenkopi Wash Downstream Sites (Locations 25, 26, 155), Long-term Runoff and Baseflow Water Quality Summary [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	64	4	0.5	1650.0	450.0	295.5	421.4	267	93.7	738.3	1,214.5
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	51	31	0.04	12.7	2.3	0.4	3.9	0.25	169.9	1.4	9.0
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	64	16	1.0	1,200.0	143.0	53.0	238.8	42.5	167.0	142.5	688.5
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	49	36	1.0	51.0	5.7	1.0	13.7	0	240.9	2.0	24.6
Bicarbonate	NNS			76	0	57.0	978.4	174.5	122.5	141.9	40.5	81.3	203.1	421.4
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	76	18	20.0	600.0	117.1	80.0	103.0	30.0	88.0	140.0	309.0
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	64	47	4.0	280.0	69.0	20.0	92.0	15.0	133.3	90.0	256.0
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	51	47	5.0	100.0	30.0	7.5	46.7	2.0	155.7	31.8	86.4
Calcium	NNS			79	0	13.0	638.0	167.8	108.0	150.2	75.0	89.5	245.0	496.0
Chloride	Aquatic & Wildlife (HT)	230	NCNS	79	1	1.0	180.0	23.2	12.3	30.5	4.3	131.5	20.8	82.9
Chromium, µg/l (T)	Livestock (both)	1000	1000	64	18	10.0	1,900.0	449.4	300.0	449.5	215.0	100.0	675.0	1,350.0
Chromium, µg/l (D)	NNS			48	47	30.0	30.0	30.0	30.0	N/A	N/A	N/A	30.0	30.0
Conductivity	<1.5 x background (HT)	NCNS	NCNS	51	1	122.0	5,320.0	1,386.2	845.0	1,353.2	468.0	97.6	1,905.0	4,627.0
Copper, µg/l (T)	Livestock (HT)	500	500	64	10	10.0	2,800.0	626.3	375.0	684.5	235.0	109.3	730.0	2,138.5
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	51	41	10.0	20.0	11.0	10.0	3.2	0	28.7	10.0	15.5
Fluoride	Full Body Contact (HT)	56,000	NCNS	79	0	0.10	0.80	0.49	0.50	0.18	0.10	36.84	0.60	0.80
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	74	4	0.1	2,520.0	446.0	263.0	528.6	230.6	118.5	578.8	1,457.5
Iron (D)	NNS			76	27	0.0	3.6	0.3	0.1	0.8	0.07	227.1	0.2	1.9
Lead, µg/l (T)	Full Body Contact (HT)	15	100	64	22	20.0	3,000.0	625.9	350.0	714.9	181.5	114.2	787.5	2,475.0
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	48	43	60.0	160.0	100.0	80.0	43.0	20	43.0	130.0	154.0
Magnesium	NNS			78	0	0.6	458.0	77.0	35.3	103.2	25.3	134.1	89.4	310.5
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	74	1	0.03	121.00	12.12	6.50	18.02	4.56	148.60	12.30	41.48
Manganese (D)	NNS			76	25	0.01	6.20	0.42	0.05	1.10	0.04	260.04	0.28	2.50
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	25	18	1.00	2.00	1.86	2.00	0.38	0	20.35	2.00	2.00
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	79	6	0.12	47.88	2.89	1.28	6.41	0.79	222.13	2.28	7.68
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	76	25	0.01	0.30	0.08	0.06	0.07	0.03	78.10	0.11	0.22
NO3 + NO2	Livestock (NN)	0.132	0.132	43	1	0.19	25.70	2.59	1.65	4.00	0.55	154.48	2.31	7.18
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	73	0	6.80	8.70	7.62	7.60	0.37	0.20	4.90	7.90	8.24
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	64	32	1.00	87.00	8.69	3.00	16.43	2.00	189.17	9.00	28.10
Sodium	NNS			78	0	9.0	778.0	104.1	54.0	138.7	24.9	133.3	95.5	413.9
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	79	0	80.0	7,750.0	1,338.3	690.0	1481.6	406.0	110.7	1714.0	4,605.0
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	76	3	8.0	132,000.0	29,855.1	17,360.0	32,612.1	12,840.0	109.2	45,500.0	96,462.0
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	79	0	3.0	4,880.0	760.2	383.0	944.4	263.0	124.2	861.5	2,974.0
Vanadium, µg/l (T)	Livestock (HT)	100	100	64	7	8.0	3,180.0	867.2	600.0	861.9	390.0	99.4	1,180.0	2,840.0
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	51	47	10.0	60.0	35.0	35.0	20.8	15.0	59.5	45.0	57.0
Zinc (T)	Agricultural Water Supply (HT)	10	25	64	4	0.02	9.90	2.32	1.31	2.54	1.00	109.55	3.05	8.60
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	51	28	0.01	0.30	0.05	0.03	0.06	0.01	123.61	0.06	0.14

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.19 Dinnebito Wash Upstream Sites (Location 78), Long-term Runoff and Baseflow Water Quality Summary [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	21	0	3.3	1,340.0	365.5	119.0	468.5	109.49	128.2	519.0	1,260.0
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	15	14	0.1	0.1	0.1	0.1	N/A	N/A	N/A	0.1	0.1
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	21	0	1.0	800.0	105.7	38.0	182.7	35.0	172.9	100.0	300.0
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	15	11	1.0	2.0	1.8	2.0	0.5	0	28.6	2.0	2.0
Bicarbonate	NNS			24	0	39.0	364.0	118.0	83.5	77.5	24.94	65.6	158.5	239.1
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	24	1	20.0	150.0	82.2	70.0	38.5	20	46.8	100.0	150.0
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	21	15	10.0	130.0	77.8	90.0	48.3	33.5	62.0	112.8	126.8
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			24	0	32.0	412.0	186.6	163.0	97.5	56	52.3	248.0	339.7
Chloride	Aquatic & Wildlife (HT)	230	NCNS	24	0	3.0	55.0	22.5	17.5	16.0	8.5	71.2	28.8	52.0
Chromium, µg/l (T)	Livestock (both)	1000	1000	21	2	10.0	1,300.0	394.2	190.0	455.0	170	115.4	485.0	1,255.0
Chromium, µg/l (D)	NNS			14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	20	0	315.0	3,380.0	1,470.0	1,324.5	868.6	472.5	59.1	1,774.5	3,256.5
Copper, µg/l (T)	Livestock (HT)	500	500	21	3	10.0	2,560.0	639.4	255.0	814.0	235.0	127.3	742.5	2,254.0
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	15	12	10.0	10.0	10.0	10.0	0.0	0	0.0	10.0	10.0
Fluoride	Full Body Contact (HT)	56,000	NCNS	24	0	0.4	0.9	0.6	0.6	0.1	0.1	23.3	0.8	0.8
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	22	0	1.6	2,130.0	568.5	171.5	714.7	153.8	125.7	1,267.5	1,714.0
Iron (D)	NNS			24	12	0.01	0.10	0.04	0.03	0.03	0.01	78.9	0.04	0.1
Lead, µg/l (T)	Full Body Contact (HT)	15	100	21	8	40.0	1,600.0	642.3	340.0	595.0	300.0	92.6	1,300.0	1,540.0
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	14	12	20.0	20.0	20.0	20.0	0.0	0	0.0	20.0	20.0
Magnesium	NNS			24	0	9.0	338.0	99.0	73.0	86.9	26.7	87.7	107.5	297.4
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	22	0	0.06	41.10	12.70	3.34	15.77	3.27	124.18	28.6	40.0
Manganese (D)	NNS			24	4	0.01	1.52	0.18	0.03	0.42	0.01	230.70	0.06	1.31
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	1	0	3.00	3.00	3.00	3.00	N/A	N/A	N/A	3.00	3.00
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	24	0	0.34	4.10	1.35	0.96	1.02	0.34	75.57	1.35	3.10
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	24	5	0.01	0.30	0.05	0.03	0.07	0.02	125.91	0.07	0.15
NO3 + NO2	Livestock (NN)	0.132	0.132	23	0	0.34	3.32	1.28	0.97	0.90	0.31	70.10	1.32	3.16
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	24	0	6.60	8.00	7.47	7.45	0.36	0.30	4.82	7.80	7.90
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	21	9	1.00	40.00	10.00	4.50	12.62	3.00	126.20	11.50	34.50
Sodium	NNS			24	0	8.0	300.0	97.9	79.5	73.3	34.0	74.9	114.8	245.4
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	24	0	180.0	3,410.0	1,502.8	1,239.0	971.3	358.0	64.6	1,882.5	3,358.5
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	24	0	28.0	109,000.0	20,868.6	6,455.0	29,182.2	6,261.0	139.8	32,067.5	80,895.0
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	24	0	91.0	2,321.0	957.9	786.0	679.0	241.0	70.9	1,112.5	2,307.3
Vanadium, µg/l (T)	Livestock (HT)	100	100	21	1	20.0	2,460.0	702.2	261.5	861.5	241.5	122.7	970.0	2,403.0
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	15	15	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Zinc (T)	Agricultural Water Supply (HT)	10	25	21	0	0.02	7.60	1.86	0.62	2.53	0.57	135.76	2.50	7.4
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	15	10	0.02	0.03	0.03	0.03	0.01	0	21.07	0.03	0.03

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-1.20 Dinnebito Wash Downstream Sites (Location CG34), Long-term Runoff and Baseflow Water Quality Summary [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	22	0	14.3	2460.0	541.7	135.5	737.6	118.8	136.2	807.8	2,247.0
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	15	10	0.1	0.5	0.2	0.1	0.2	0.02	94.2	0.2	0.4
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	22	1	3.0	300.0	80.9	22.0	93.8	16	116.0	110.0	280.0
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	15	7	1.0	2.0	1.5	1.5	0.5	0.5	35.6	2.0	2.0
Bicarbonate	NNS			24	0	43.9	227.0	98.3	87.5	44.1	19.5	44.9	109.0	171.2
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	24	1	20.0	880.0	103.5	70.0	173.2	30.0	167.4	100.0	140.0
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	22	16	6.0	440.0	138.2	71.5	166.6	58.5	120.6	187.5	385.0
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	13	13	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			24	0	16.0	435.0	159.1	149.5	125.6	106	78.9	240.8	389.4
Chloride	Aquatic & Wildlife (HT)	230	NCNS	24	1	2.0	55.0	16.9	12.0	15.3	8	90.7	21.0	40.9
Chromium, µg/l (T)	Livestock (both)	1000	1000	22	2	10.0	2,300.0	559.0	210.0	709.0	195	126.8	792.5	2,176.5
Chromium, µg/l (D)	NNS			13	13	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	20	0	142.0	3,140.0	1,189.0	713.5	1,005.7	542.0	84.6	1,659.8	2,988.0
Copper, µg/l (T)	Livestock (HT)	500	500	22	0	10.0	4,140.0	814.1	165.0	1,206.4	145.0	148.2	1,000.0	3,555.0
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	15	14	10.0	10.0	10.0	10.0	N/A	N/A	N/A	10.0	10.0
Fluoride	Full Body Contact (HT)	56,000	NCNS	24	0	0.4	1.0	0.6	0.6	0.2	0.1	29.3	0.7	1.0
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	21	0	13.8	2,960.0	685.7	148.0	939.3	130.4	137.0	990.0	2,440.0
Iron (D)	NNS			24	11	0.01	0.23	0.08	0.06	0.06	0.04	75.81	0.10	0.17
Lead, µg/l (T)	Full Body Contact (HT)	15	100	22	7	40.0	3600.0	961.3	500.0	1088.3	400.0	113.2	1490.0	3,180.0
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	13	12	60.0	60.0	60.0	60.0	N/A	N/A	N/A	60.0	60.0
Magnesium	NNS			24	0	4.0	205.0	67.9	51.5	68.9	37.15	101.4	82.9	190.6
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	21	0	0.3	56.4	12.5	3.1	16.4	2.8	131.4	19.0	42.1
Manganese (D)	NNS			24	8	0.01	0.22	0.04	0.02	0.06	0.01	125.4	0.05	0.13
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	2	1	6.00	6.0	6.0	6.0	N/A	N/A	N/A	6.0	6.0
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	24	0	0.99	8.1	2.7	2.3	1.7	0.76	65.0	2.9	6.0
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	24	8	0.02	0.3	0.1	0.0	0.1	0.015	111.0	0.1	0.3
NO3 + NO2	Livestock (NN)	0.132	0.132	23	0	1.0	6.1	2.5	2.3	1.4	0.76	54.8	2.9	5.5
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	24	0	6.9	8.2	7.6	7.7	0.3	0.2	4.3	7.8	8.1
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	22	6	1.0	75.0	11.4	3.5	22.2	23.0	195.2	5.3	63.8
Sodium	NNS			24	0	4.0	215.0	71.9	54.0	67.8	36.0	94.4	86.0	206.7
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	24	0	88.0	3,094.0	1,139.6	927.0	993.3	694	87.2	1,660.0	2,978.8
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	24	0	276.0	129,000.0	29,145.4	9,600.0	38,151.3	9,259.5	130.9	42,893.8	100,902.5
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	24	0	29.0	2,118.0	713.2	590.5	686.2	463.5	96.2	1,050.0	1,969.9
Vanadium, µg/l (T)	Livestock (HT)	100	100	21	0	29.0	4,240.0	1,039.6	230.0	1,339.8	200.0	128.9	1,500.0	3,680.0
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	15	15	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Zinc (T)	Agricultural Water Supply (HT)	10	25	22	0	0.07	11.90	2.88	0.66	3.86	0.58	134.35	4.45	10.9
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	15	10	0.01	0.03	0.02	0.01	0.01	0	55.90	0.02	0.03

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

This page intentionally left blank

Appendix WR-2

Pond Water Quality Characterizations PWCC Leasehold

This page intentionally left blank

Appendix WR-2 Pond Water Quality and Management

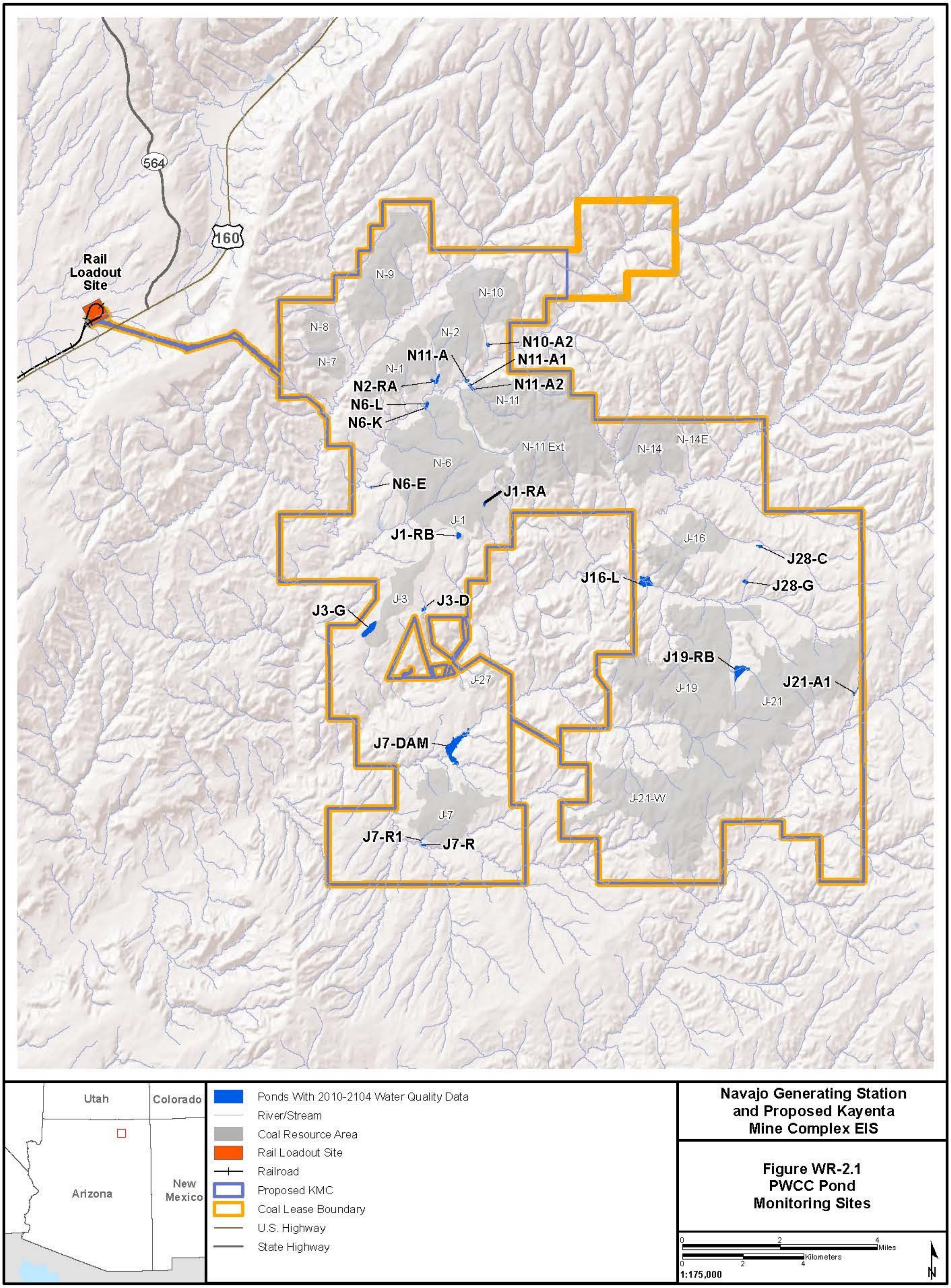
PWCC pond monitoring locations over time are indicated in **Figure WR-2.1**. Recent data indicate that monitored ponds in the J1/J3/J7 area (southwestern part of the lease area) exceed the most protective water quality criterion for total aluminum about 70 percent of the time, and total iron about 40 percent of the time. Total aluminum was not detected in about 22 percent of the samples, and total iron was not detected in 13 percent of samples. There were no exceedances for dissolved aluminum or iron, neither of which is detected in about a quarter of the samples. Exceedances of other constituents either do not occur or occur only infrequently (less than 10 percent of the samples). Total suspended solids are not detected in 13 out of 23 samples, and are generally low in the remainder. Livestock water quality criteria are consistently met (all concentrations below applicable values), with the exception of pH. One elevated pH value (9.5) occurs in data.

In ponds monitored in the J16/J19/J28/J21 area (eastern part of the lease area), total aluminum and total iron concentrations exceed the most protective water quality criteria in about 45 and 30 percent of the samples, respectively. Total aluminum is not detected in the remainder, and total iron is infrequently detected in the remainder. Dissolved aluminum and iron are not detected. Total dissolved solids concentrations exceed the most protective criteria in about 70 percent of samples. Sulfate and chloride values exceed their most protective criteria in about 45 and 20 percent of the samples, respectively. No other constituents exceed the most protective criteria, and there are many non-detected values. Total suspended solids are not detected in most samples, and are quite low in the remainder. All constituent concentrations are consistently within livestock criteria.

Recently monitored ponds in the N10/N11/N2/N6 area (northern part of the lease area) indicate that total aluminum exceeds its most protective water quality criterion in 25 percent of samples. Aluminum is not detected in about 60 percent of samples. Total iron concentrations exceed the most protective criterion less than ten percent of the time, and are undetected in about 40 percent of samples. Dissolved iron is not detected. Total dissolved solids and sulfate concentrations consistently exceed their most protective criteria. Selenium concentrations exceed the most protective criterion (2 µg/L) in 50 percent of samples, and are not detected in the other 50 percent. Total suspended solids concentrations are either low or not detected. All other constituents that have applicable livestock criteria have concentrations consistently within those criteria, except for one elevated pH value (9.3). See **Tables WR-2.1** through **WR-2.3** here for further detail.

Evaporative conditions exist at all of the retention ponds at KMC. Pond discharges are managed by pumping, and timed according to retained volumes, available storage at nearby ponds, water quality, flow occurrence, and permit conditions. If runoff or wastewater is retained in ponds for a considerable period, evaporation may maintain or slightly increase the levels of constituents such as TDS or sulfate. This may be reflected in the respective data for the N10/N11/N2/N6 pond samples.

Although total aluminum and total iron concentrations in ponds commonly exceed the most protective water quality criteria, their values in pond samples are all less than five percent of corresponding values in runoff-generated streamflows. Typical concentrations of these constituents in pond samples are usually one percent or less than their typical values in storm water runoff or mixed runoff/baseflow samples from streams. Large reductions of most other total trace metal concentrations are reflected in pond data compared to runoff data. Total suspended solids data also indicate substantial reductions in ponds compared to streamflows from runoff.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-2.1
PWCC Pond Monitoring Sites

7/20/2016

Table WR-2.1 Ponds J1, J3, J7 Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	17	2	0.04	47.40	12.05	1.91	16.82	1.87	139.60	28.18	39.23
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	23	6	0.04	0.81	0.25	0.12	0.26	0.08	105.47	0.28	0.75
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	17	0	0.60	13.90	4.28	2.20	3.92	0.70	91.61	5.00	12.00
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	15	0	0.80	6.80	2.31	2.10	1.43	0.40	61.80	2.45	4.42
Bicarbonate	NNS			23	0	32	256	147	141	60	40	41	187	243
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	23	1	20	380	85	70	72	20	85	90	158
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	17	14	0.20	1.00	0.53	0.40	0.42	0.20	78.06	0.70	0.94
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	23	23	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			23	0	7.1	214.0	41.1	34.6	41.0	14.6	99.9	47.0	66.8
Chloride	Aquatic & Wildlife (HT)	230	NCNS	23	0	2.0	220.0	33.2	15.0	46.6	11.0	140.7	46.0	76.4
Chromium, µg/l (T)	Livestock (both)	1000	1000	17	13	30.0	50.0	40.0	40.0	8.2	5.0	20.4	42.5	48.5
Chromium, µg/l (D)	NNS			23	23	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	23	0	142.0	1800.0	431.7	406.0	324.7	122.0	75.2	465.5	560.2
Copper, µg/l (T)	Livestock (HT)	500	500	17	13	20.0	40.0	32.5	35.0	9.6	5.0	29.5	40.0	40.0
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	23	9	0.60	20.0	5.4	4.1	4.9	2.0	90.0	7.1	12.5
Fluoride	Full Body Contact (HT)	56,000	NCNS	23	0	0.20	0.9	0.4	0.4	0.2	0.1	39.1	0.5	0.8
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	23	3	0.03	28.8	6.8	1.0	9.9	1.0	146.2	10.4	23.9
Iron (D)	NNS			23	7	0.03	0.38	0.12	0.09	0.10	0.04	83.18	0.13	0.32
Lead, µg/l (T)	Full Body Contact (HT)	15	100	17	6	0.20	50.0	12.5	4.5	17.3	4.2	138.2	20.3	41.6
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	23	16	0.20	0.90	0.37	0.20	0.26	0	70.75	0.45	0.78
Magnesium	NNS			23	0	3.1	105.0	15.3	13.3	20.3	6.3	132.8	14.7	22.1
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	23	2	0.01	0.79	0.22	0.10	0.26	0.07	119.30	0.40	0.73
Manganese (D)	NNS			23	5	0.01	0.38	0.11	0.05	0.12	0.05	106.22	0.16	0.30
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	23	23	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	23	7	0.0	2.94	0.33	0.10	0.71	0.07	213.89	0.24	1.17
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	23	16	0.0	0.31	0.10	0.04	0.10	0.01	107.20	0.12	0.26
NO3 + NO2	Livestock (NN)	0.132	0.132	23	7	0.0	3.07	0.38	0.17	0.74	0.14	197.07	0.37	1.28
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	23	0	7.1	10.6	8.4	8.3	0.8	0.5	9.8	8.8	9.9
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	17	16	2.0	2.0	2.0	2.0	0	0	0	2.0	2.0
Sodium	NNS			23	0	0.7	59.2	22.7	19.9	18.2	13.3	80.4	34.4	57.1
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	23	0	90.0	1360.0	350.9	270.0	331.4	90.0	94.4	355.0	1235.0
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	23	13	15.0	820.0	128.4	40.5	246.4	20.5	191.9	96.3	512.2
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	23	5	6.0	510.0	83.9	31.0	124.8	17.4	148.8	111.5	297.5
Vanadium, µg/l (T)	Livestock (HT)	100	100	17	5	6.0	113.0	44.4	20.0	40.4	13.5	91.1	84.5	105.9
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	21	16	6.0	14.0	9.2	8.0	3.3	2.0	35.6	11.0	13.4
Zinc (T)	Agricultural Water Supply (HT)	10	25	17	11	0.04	0.16	0.11	0.14	0.06	0.03	48.54	0.16	0.16
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	21	20	0.02	0.02	0.02	0.02	N/A	N/A	N/A	0.02	0.02

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-2.2 Ponds J16L, J19RB, J21A1, J28C, J28G Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	7	4	0.64	2.63	1.31	0.67	1.14	0.03	86.83	1.65	2.43
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	7	5	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.05	0.05
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	7	3	1.00	2.00	1.38	1.25	0.45	0.20	32.73	1.55	1.91
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	1	1	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Bicarbonate	NNS			7	0	71.0	214.0	130.7	109.0	58.6	38.0	44.9	179.0	204.7
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	7	0	30.0	410.0	165.7	180.0	138.4	130.0	83.5	225.0	359.0
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NNS			7	0	41.7	271.0	116.1	99.7	78.2	41.7	67.4	133.0	237.4
Chloride	Aquatic & Wildlife (HT)	230	NCNS	7	1	2.0	540.0	169.8	116.5	197.8	78.0	116.5	195.0	455.0
Chromium, µg/l (T)	Livestock (both)	1000	1000	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	7	0	292.0	2,320.0	1,233.4	936.0	842.1	594.0	68.3	1,920.0	2,317.0
Copper, µg/l (T)	Livestock (HT)	500	500	7	5	20.0	30.0	25.0	25.0	7.1	5.0	28.3	27.5	29.5
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	7	6	20.0	20.0	20.0	20.0	N/A	N/A	N/A	20.0	20.0
Fluoride	Full Body Contact (HT)	56,000	NCNS	7	1	0.5	1.2	0.6	0.5	0.3	0.0	44.3	0.6	1.1
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	7	4	0.2	1.5	0.9	1.0	0.7	0.5	70.3	1.3	1.5
Iron (D)	NNS			7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	Full Body Contact (HT)	15	100	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			7	0	7.7	145.0	63.7	50.7	52.3	43.0	82.1	98.5	134.5
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	7	0	0.0	1.2	0.3	0.1	0.5	0.0	137.9	0.5	1.1
Manganese (D)	NNS			7	1	0.0	1.2	0.4	0.2	0.5	0.1	123.8	0.7	1.1
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	7	1	0.2	5.4	1.4	0.6	2.0	0.3	147.6	1.0	4.3
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	7	1	0.0	0.1	0.1	0.0	0.0	0.0	72.7	0.1	0.1
NO3 + NO2	Livestock (NN)	0.132	0.132	7	0	0.0	5.5	1.2	0.5	1.9	0.3	159.7	0.9	4.2
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	7	0	7.8	8.5	8.1	8.1	0.2	0.2	3.1	8.3	8.4
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	7	6	3.0	3.0	3.0	3.0	N/A	N/A	N/A	3.0	3.0
Sodium	NNS			7	0	3.6	154.0	56.2	30.4	56.6	26.8	100.7	89.0	137.8
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	7	0	190.0	2,030.0	865.7	600.0	660.7	410.0	76.3	1,210.0	1,826.0
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	7	5	9.0	17.0	13.0	13.0	5.7	4.0	43.5	15.0	16.6
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	7	0	65.0	1,180.0	357.1	250.0	389.0	150.0	108.9	400.0	952.0
Vanadium, µg/l (T)	Livestock (HT)	100	100	7	5	8.0	8.0	8.0	8.0	0.0	0.0	0.0	8.0	8.0
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	5	4	7.0	7.0	7.0	7.0	N/A	N/A	N/A	7.0	7.0
Zinc (T)	Agricultural Water Supply (HT)	10	25	7	6	0.3	0.3	0.3	0.3	N/A	N/A	N/A	0.3	0.3
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	7	6	0.29	0.29	0.29	0.29	N/A	N/A	N/A	0.29	0.29

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-2.3 Ponds N2-R, N6-E, N6-K, N6-L, N10-A2, N11-A, N11-A1, N11-A2 Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	12	7	0.07	3.88	1.04	0.48	1.61	0.41	154.18	0.72	3.25
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	12	7	0.04	0.80	0.21	0.08	0.33	0.03	153.48	0.10	0.66
Arsenic, µg/l (T)	Full Body Contact (HT)	30	200	12	8	1.40	3.00	1.83	1.45	0.78	0	43.00	1.88	2.78
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	7	4	0.70	1.20	0.97	1.00	0.25	0.20	26.03	1.10	1.18
Bicarbonate	NNS			12	0	48.00	392.00	154.58	98.50	116.86	24	75.59	187.25	368
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	12	0	50.00	800.00	213.33	145.00	205.22	55	96.20	217.50	575
Cadmium, µg/l (T)	Fish Consumption (NN)	8	50	12	12	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	12	11	6.00	6.00	6.00	6.00	N/A	N/A	N/A	6.00	6
Calcium	NNS			12	0	21.20	552.00	257.43	214.50	194.33	153.3	75.49	398.75	548.2
Chloride	Aquatic & Wildlife (HT)	230	NCNS	12	0	11.00	530.00	95.42	47.50	142.63	24.5	149.48	105.00	310.0
Chromium, µg/l (T)	Livestock (both)	1000	1000	12	12	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			12	12	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	12	0	315	18,200	3,705	2,735	4,725	1,260.0	128	3,373	10,615.5
Copper, µg/l (T)	Livestock (HT)	500	500	12	11	20.00	20.00	20.00	20.00	N/A	N/A	N/A	20.00	20.0
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	12	9	2.00	4.30	2.93	2.50	1.21	0.5	41.24	3.40	4.1
Fluoride	Full Body Contact (HT)	56,000	NCNS	12	0	0.20	2.30	0.83	0.70	0.55	0.3	66.19	1.10	1.6
Iron (T)	Aquatic & Wildlife, chronic (HT)	1.0	NCNS	12	5	0.05	1.15	0.30	0.15	0.39	0.1	129.17	0.27	0.9
Iron (D)	NNS			12	12	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	Full Body Contact (HT)	15	100	12	8	0.40	1.50	0.90	0.85	0.58	0.5	64.79	1.35	1.5
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	12	12	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			12	0	14.80	1,520.00	298.49	141.50	425.93	100.50	142.69	317.25	995.85
Manganese (T)	Agricultural Water Supply (HT)	10,000	NCNS	12	2	0.02	3.34	0.89	0.10	1.35	0.06	151.66	1.73	3.12
Manganese (D)	NNS			12	2	0.01	3.28	0.88	0.10	1.35	0.07	153.20	1.70	3.10
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	12	11	0.30	0.30	0.30	0.30	N/A	N/A	N/A	0.30	0.30
Nitrate as N	Full Body Contact (HT)	1,493	NCNS	12	3	0.04	10.30	2.49	1.60	3.06	0.35	122.50	1.95	7.43
Nitrite as N	Full Body Contact (HT)	93.3	NCNS	12	4	0.02	0.13	0.08	0.08	0.04	0.04	54.64	0.11	0.13
NO3 + NO2	Livestock (NN)	0.132	0.132	12	3	0.05	10.30	2.56	1.73	3.04	0.32	118.82	2.05	7.48
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	12	0	8.00	9.30	8.19	8.00	0.39	0.00	4.76	8.13	8.92
Selenium, µg/l (T)	Aquatic & Wildlife, chronic (both)	2	50	12	6	5.00	9.30	7.35	7.40	1.86	1.50	25.27	8.93	9.23
Sodium	NNS			12	0	12.30	3,590.00	458.45	131.50	995.49	50.0	217.14	232.25	1,908.7
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	12	0	160	21,300	3,845	2,490	5,696	1,370.0	148	3,408	12,434.0
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	12	5	6.00	19.00	12.29	10.00	5.53	4.0	45.00	17.50	18.7
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	12	0	65.00	11,900.00	2,232.92	1,490.00	3,182.02	875.0	142.51	2,115.00	7,115.0
Vanadium, µg/l (T)	Livestock (HT)	100	100	12	10	13.00	15.00	14.00	14.00	1.41	1.00	10.10	14.50	14.90
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	12	8	6.00	20.00	14.25	15.50	6.24	3.50	43.78	18.50	19.70
Zinc (T)	Agricultural Water Supply (HT)	10	25	12	10	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.03	0.03
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	12	8	0.02	0.50	0.15	0.04	0.24	0.01	159.42	0.16	0.43

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

This page intentionally left blank

Appendix WR-3

Spring Flows and Water Quality PWCC Leasehold

This page intentionally left blank

Appendix WR-3. Characteristics of Springs in the Coal Leasehold

Flows at springs monitored by PWCC are summarized in **Table WR-3.1**. Spring monitoring locations are depicted in **Figure WR-3.1**.

In the northern part of the coal lease areas, water quality at spring sites NSPG91, NSPG95, and NSPG111 (**Table WR-3.2**) reflect a magnesium sulfate or mixed sulfate type, with TDS generally greater than 5,000 mg/L. These sites are relatively far up the geologic section on the mesa, yet still reflect a Wepo Formation origin. Sulfate values are generally near or above 4,000 mg/L. Trace element concentrations are low, with the possible exception of boron. No livestock water quality criteria are exceeded, but the most protective criteria are exceeded by boron in 25 percent of samples and by total iron in about 30 percent of samples. The Hopi tribal standard for boron is for Agricultural Irrigation, and for iron it is Warm Water Aquatic and Wildlife Use (chronic). Sulfate and TDS consistently exceed their most protective criteria, which involve standards for several different beneficial uses.

Springs summarized in **Table WR-3.3** are located along Coal Mine Wash as it descends through the northern KMC mine areas. Recent sampling data reflect a mixed sulfate or sodium sulfate type, with variable TDS concentrations. Data from Site NSPG21 indicates lower concentrations of TDS, sulfate, calcium, magnesium and sodium, and chloride. Other springs nearby and downstream have higher but variable concentrations of these constituents. Total cadmium and total aluminum exceed their most protective water quality criteria in 25 percent and about 30 percent of samples, respectively. Selenium concentrations exceed the most protective criterion in about 20 percent of samples, and TDS and sulfate consistently exceed their most protective criteria. Livestock water quality standards are met by all detected constituents except dissolved aluminum, which exceeds its criterion (5 mg/L) in about 15 percent of samples.

Springs NSPG92 and NSPG147 (**Table WR-3.4**) are along a small ridge that parallels Moenkopi Wash in the southwestern part of the coal lease area. Mining activity has not occurred along this ridge, and canyons along Moenkopi Wash and its tributaries separate the spring locations from mining activities that are a mile away or more (**Figure WR-3.1**). Recent water quality from these springs reflects a sodium sulfate type, with TDS generally 6,000 to 12,000 mg/L. There also is a high proportion of selenium exceedances of the chronic aquatic and wildlife habitat criterion (2 µg/L). These sites also have the most consistently high concentrations of boron. Livestock water quality standards are met by all constituents detected in samples.

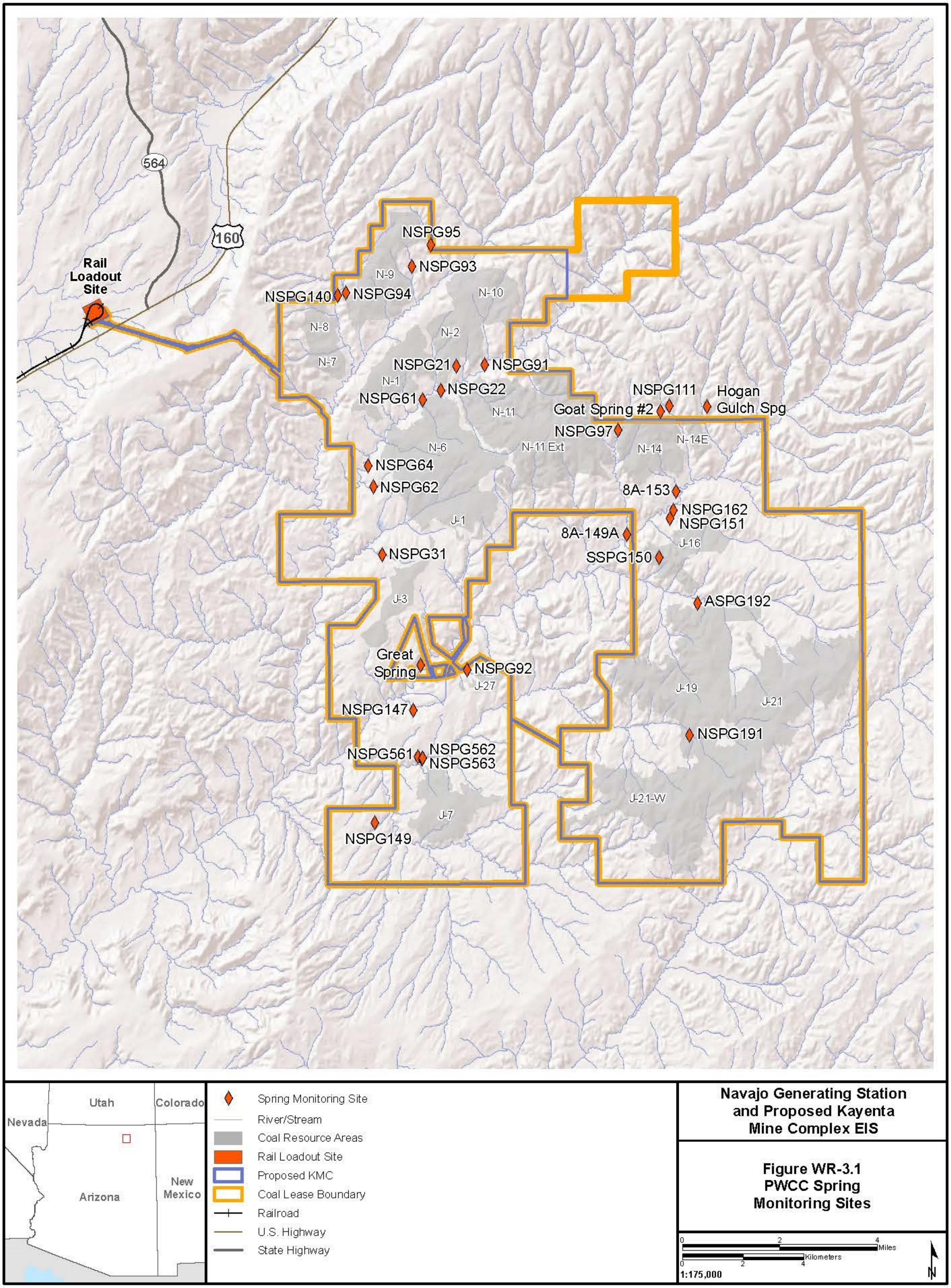
Springs NPGS151 and NSPG162 are located along Moenkopi Wash in the eastern part of the coal lease area, near mine operations area J16 (**Figure WR-3.1**). Recent water quality from these springs reflects a mixed sulfate or sodium sulfate type, with TDS ranging between 6,650 to 12,800 mg/L in recent samples. Sulfate concentrations are over 4,000 mg/L. NSPG162 consistently has bicarbonate concentrations below detection limits, and is markedly acidic. The maximum recorded flow from NSPG 162 is 0.5 gallons per minute, and the average and median flows are quite small (**Table WR-3.1**). Selenium concentrations consistently exceed both wildlife and livestock criteria at both springs. Dissolved cadmium, chloride, and zinc concentrations also exceed their most protective criteria in about 30 to 55 percent of samples. Depending on tribal criteria, boron exceedances occur in 50 to 100 percent of recent samples at these springs.

Table WR-3.1 Flow Summary for Commonly Monitored Springs within the Coal Lease Areas (gallons per minute)[1]

Spring Site	Period of Record	Record Count	Minimum Flow (gpm)	Maximum Flow (gpm)	Mean Flow (gpm)	Median Flow (gpm) or Most Common Condition
NSPG21	08/2003 – 08/2010	33	0.00	40.00	3.11	Not flowing
NSPG22	02/2005 – 02/2011	16	0.000	1.00	0.15	0.10
NSPG61	05/2008 – 01/2011	5	0.21	0.56	0.39	0.38
NSPG91	09/1980 – 02/2011	30	0.19	3.00	1.33	1.28
NSPG92	11/1980 – 05/2010	30	0.000	89.76	3.51	0.06
NSPG93	04/2008 – 03/2011	5	0.000	0.00	0.00	Not flowing
NSPG97	10/1980 – 09/1982	3	0.13	0.53	0.40	0.53
NSPG111	10/1980 – 04/2010	28	0.00	2.00	0.14	0.02
NSPG140	10/1981 – 04/2001	16	0.00	0.10	0.01	Not flowing
NSPG147	06/1989 – 04/2010	212	0.03	3.60	0.59	0.48
NSPG151	04/2010 – 03/2011	10	0.00	1.50	0.63	0.50
NSPG162	03/2003 – 02/2011	63	0.00	0.50	0.03	Not flowing
NSPG191	02/2003 – 07/2010	22	0.00	4.00	0.55	Not flowing
NSPG561	03/2007 – 03/2010	12	0.10	240.00	32.46	6.61
NSPG562	03/2007 – 03/2010	12	0.06	5.75	2.00	1.88
NSPG563	03/2007 – 03/2010	13	0.15	7.93	3.63	2.11
NSPGGOAT#2	05/1999 – 09/1999	2	0.004	0.20	0.10	0.10
NSPGHOGAN	05/1999 – 09/1999	2	0.0003	0.01	0.01	0.01
SSPG150	10/1999 – 09/2010	52	0.00	1.00	0.02	Not flowing
SSPG151	05/2000 – 12/2009	88	0.00	60.00	5.80	1.50

[1] Locations are indicated on **Figure WR-3.1**. NSPG: "Native Spring site." SSPG: "Spoil Spring site."

Source: PWCC 2012 et seq.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-3.1
PWCC Spring Monitoring Sites

This page intentionally left blank

Table WR-3.2 Springs NSPG93, NSPG95 and NSPG111 Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	6	4	0.01	0.08	0.05	0.05	0.05	0.03	107.2	0.06	0.08
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	6	3	0.04	0.06	0.05	0.05	0.01	0.01	20.00	0.06	0.06
Arsenic, µg/l (T)	Primary Contact Ceremonial (HT)	10	200	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Bicarbonate	NNS			7	0	298.0	758.0	491.7	382.0	199.8	84.00	40.64	671.0	743.9
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	7	0	170.0	1,050	497.1	420.0	343.6	240.0	69.10	720.0	975.0
Cadmium, µg/l (T)	Primary Contact Ceremonial (HT)	5	50	6	5	0.60	0.60	0.60	0.60	N/A	N/A	N/A	0.60	0.60
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	7	6	0.60	0.60	0.60	0.60	N/A	N/A	N/A	0.60	0.60
Calcium	NNS			7	0	450.0	503.0	484.3	489.0	17.09	6.00	3.53	492.5	500.6
Chloride	Aquatic & Wildlife (HT)	230	NCNS	7	0	56.00	160.00	99.43	80.00	41.85	8.00	42.09	123.0	159.4
Chromium, µg/l (T)	Livestock (both)	1000	1000	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	7	0	4,550	9,370	6,424	5,670	1,769	320.0	27.53	7,200	9,088
Copper, µg/l (T)	Livestock (HT)	500	500	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	7	6	20.00	20.00	20.00	20.00	N/A	N/A	N/A	20.00	20.00
Fluoride	Primary Contact Ceremonial (HT)	4	NCNS	7	0	1.20	4.80	2.81	1.79	1.65	0.59	58.83	4.45	4.71
Iron (T)	Primary Contact Ceremonial (HT)	0.3	NCNS	7	3	0.40	3.20	1.63	1.45	1.44	1.05	88.81	2.68	3.10
Iron (D)	NNS			7	6	0.44	0.44	0.44	0.44	N/A	N/A	N/A	0.44	0.44
Lead, µg/l (T)	Primary Contact Ceremonial (HT)	15	100	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			7	0	501.0	1,280	910.9	840.0	268.8	12.00	29.51	1,044	1,268
Manganese (T)	Primary Contact Ceremonial (HT)	0.05	NCNS	7	0	0.11	2.75	0.87	0.40	0.99	0.09	113.2	1.11	2.45
Manganese (D)	NNS			7	0	0.08	2.64	0.85	0.40	0.96	0.08	112.8	1.08	2.36
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Primary Contact Ceremonial (HT)	10	NCNS	7	2	0.03	43.00	8.82	0.08	19.11	0.05	216.62	0.94	34.59
Nitrite as N	Primary Contact Ceremonial (HT)	1.0	NCNS	7	6	0.02	0.02	0.02	0.02	N/A	N/A	N/A	0.02	0.02
NO3 + NO2	Livestock (NN)	0.132	0.132	7	2	0.03	42.80	8.79	0.08	19.02	0.05	216.5	0.96	34.43
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	7	0	7.80	8.20	8.10	8.10	0.14	0.10	1.75	8.20	8.20
Selenium, µg/l (T)	Primary Contact Ceremonial (HT)	0.17	50	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NNS			7	0	109.0	829.0	331.7	276.0	267.9	160.0	80.76	432.5	741.4
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	7	0	4,950	10,100	7,227	6,480	1,969	330.0	27.24	8,315	10,031
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	7	2	6.00	12.00	8.60	8.00	2.79	2.00	32.47	11.00	11.80
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	7	0	2,900	6,560	4,540	4,000	1,336	320.0	29.42	5,260	6,452
Vanadium, µg/l (T)	Livestock (HT)	100	100	6	5	60.00	60.00	60.00	60.00	N/A	N/A	N/A	60.00	60.00
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	7	7	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Zinc (T)	Primary Contact Ceremonial (HT)	7.4	25	6	4	0.06	0.12	0.09	0.09	0.04	0.03	47.14	0.11	0.12
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	7	6	0.02	0.02	0.02	0.02	N/A	N/A	N/A	0.02	0.02

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-3.3 Springs NSPG21, 22, 62, and 91 Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	14	7	0.01	102.0	27.47	0.34	44.11	0.34	160.6	44.95	95.52
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	12	8	0.05	94.10	39.03	30.99	46.79	30.83	119.9	69.80	89.24
Arsenic, µg/l (T)	Primary Contact Ceremonial (HT)	10	200	14	7	0.30	4.00	1.80	0.90	1.59	0.60	88.42	3.00	4.00
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	9	8	2.20	2.20	2.20	2.20	N/A	N/A	N/A	2.20	2.20
Bicarbonate	NNS			14	2	242.0	972.0	576.5	348.5	325.2	93.50	56.41	930.0	970.9
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	14	0	90.00	500.0	244.3	145.0	178.7	45.00	73.13	435.0	500.0
Cadmium, µg/l (T)	Primary Contact Ceremonial (HT)	5	50	11	8	0.20	13.00	4.83	1.30	7.09	1.10	146.8	7.15	11.83
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	13	9	1.00	454.0	119.2	10.95	223.2	5.70	187.2	122.8	387.8
Calcium	NNS			13	0	125.0	465.0	319.2	368.0	131.7	97.00	41.24	442.0	457.8
Chloride	Aquatic & Wildlife (HT)	230	NCNS	14	1	4.00	68.00	31.77	40.00	21.68	10.00	68.25	45.00	57.20
Chromium, µg/l (T)	Livestock (both)	1000	1000	14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			12	12	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	14	0	845.0	9,320	4,572	3,670	3,314	2,040	72.49	8,248	9,008
Copper, µg/l (T)	Livestock (HT)	500	500	14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	12	10	9.00	11.30	10.15	10.15	1.63	1.15	16.02	10.73	11.19
Fluoride	Primary Contact Ceremonial (HT)	4	NCNS	14	0	0.20	1.90	0.90	0.40	0.76	0.15	84.84	1.88	1.90
Iron (T)	Primary Contact Ceremonial (HT)	0.3	NCNS	14	3	0.05	11.00	4.15	2.75	3.97	2.58	95.52	7.10	10.13
Iron (D)	NNS			14	3	0.03	9.84	3.29	1.99	3.14	1.79	95.55	4.99	8.57
Lead, µg/l (T)	Primary Contact Ceremonial (HT)	15	100	14	12	2.50	3.10	2.80	2.80	0.42	0.30	15.15	2.95	3.07
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	13	10	1.60	347.0	117.2	3.00	199.0	1.40	169.8	175.0	312.6
Magnesium	NNS			14	0	5.54	416.0	234.6	218.0	153.7	140.0	65.50	382.0	412.8
Manganese (T)	Primary Contact Ceremonial (HT)	0.05	NCNS	14	0	0.05	11.00	1.90	0.23	3.10	0.15	163.5	2.87	7.33
Manganese (D)	NNS			13	0	0.07	9.83	2.11	0.26	3.20	0.17	151.6	2.78	8.58
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Primary Contact Ceremonial (HT)	10	NCNS	14	4	0.03	3.64	1.79	1.49	1.52	1.31	84.85	3.37	3.58
Nitrite as N	Primary Contact Ceremonial (HT)	1.0	NCNS	14	13	0.02	0.02	0.02	0.02	N/A	N/A	N/A	0.02	0.02
NO3 + NO2	Livestock (NN)	0.132	0.132	14	3	0.03	3.64	1.64	0.71	1.54	0.68	93.89	3.26	3.57
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	14	0	4.20	8.30	7.52	8.05	1.40	0.10	18.61	8.18	8.30
Selenium, µg/l (T)	Primary Contact Ceremonial (HT)	0.17	50	14	10	1.90	5.80	3.73	3.60	2.01	1.60	54.06	5.28	5.70
Sodium	NNS			14	0	17.70	1,860	636.9	45.05	836.9	8.50	131.4	1,583	1,821
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	14	0	650.0	9,110	4,436	3,835	3,317	2,465	74.77	7,943	8,915
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	14	4	6.00	46.00	20.60	13.00	14.12	6.00	68.54	31.25	41.95
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	14	0	270.0	5,900	2,738	2,565	2,125	1,850	77.61	4,955	5,575
Vanadium, µg/l (T)	Livestock (HT)	100	100	14	12	7.00	9.00	8.00	8.00	1.41	1.00	17.68	8.50	8.90
Vanadium, µg/l (D)	Agric Water, Livestock (both)	100	100	10	8	8.00	40.00	24.00	24.00	22.63	16.00	94.28	32.00	38.40
Zinc (T)	Primary Contact Ceremonial (HT)	7.4	25	14	9	0.02	9.00	3.68	2.08	4.09	2.06	111.2	7.00	8.60
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	11	8	0.25	1.79	1.20	1.55	0.83	0.24	69.24	1.67	1.77

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-3.4 Springs NSPG92, 147 Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	6	3	0.07	1.10	0.41	0.07	0.60	0.01	144.8	0.59	1.00
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	5	4	0.06	0.06	0.06	0.06	N/A	N/A	N/A	0.06	0.06
Arsenic, µg/l (T)	Primary Contact Ceremonial (HT)	10	200	6	5	3.00	3.00	3.00	3.00	N/A	N/A	N/A	3.00	3.00
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	4	4	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Bicarbonate	NNS			6	0	179.0	716.0	406.0	370.0	201.78	145.5	49.70	520.5	673.5
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	6	0	160.0	4,900	3,440	3,935	1,727	645.0	50.21	4,465	4,800
Cadmium, µg/l (T)	Primary Contact Ceremonial (HT)	5	50	6	4	1.90	2.00	1.95	1.95	0.07	0.05	3.63	1.98	2.00
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	5	4	2.00	2.00	2.00	2.00	N/A	N/A	N/A	2.00	2.00
Calcium	NNS			6	0	407.0	465.0	437.8	447.0	24.85	12.50	5.67	453.0	462.3
Chloride	Aquatic & Wildlife (HT)	230	NCNS	6	0	110.0	307.0	192.8	175.0	77.77	55.00	40.33	245.0	295.3
Chromium, µg/l (T)	Livestock (both)	1000	1000	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	6	0	5,550	14,400	9,538	9,120	2,997	1,580	31.42	10,635	13,575
Copper, µg/l (T)	Livestock (HT)	500	500	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	5	3	8.00	20.00	14.00	14.00	8.49	6.00	60.61	17.00	19.40
Fluoride	Primary Contact Ceremonial (HT)	4	NCNS	6	0	0.40	1.10	0.84	0.95	0.28	0.12	33.16	1.03	1.09
Iron (T)	Primary Contact Ceremonial (HT)	0.3	NCNS	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Iron (D)	NNS			6	5	0.04	0.04	0.04	0.04	N/A	N/A	N/A	0.04	0.04
Lead, µg/l (T)	Primary Contact Ceremonial (HT)	15	100	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NNS			6	0	426.0	982.0	678.7	638.5	211.7	164.0	31.19	821.8	952.5
Manganese (T)	Primary Contact Ceremonial (HT)	0.05	NCNS	6	0	0.31	10.10	4.54	3.81	4.25	3.35	93.52	7.93	9.73
Manganese (D)	NNS			6	0	0.32	10.10	4.50	3.74	4.20	3.25	93.35	7.76	9.69
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Primary Contact Ceremonial (HT)	10	NCNS	6	1	49.50	131.0	84.00	77.00	31.29	19.30	37.25	96.30	124.1
Nitrite as N	Primary Contact Ceremonial (HT)	1.0	NCNS	6	1	0.02	0.51	0.33	0.39	0.20	0.12	61.23	0.50	0.51
NO3 + NO2	Livestock (NN)	0.132	0.132	6	1	49.50	131.0	84.12	77.00	31.25	19.50	37.15	96.50	124.1
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	6	0	7.10	8.30	7.87	7.95	0.40	0.05	5.13	8.00	8.23
Selenium, µg/l (T)	Primary Contact Ceremonial (HT)	0.17	50	6	1	1.70	14.00	7.42	6.80	4.40	1.20	59.29	8.00	12.80
Sodium	NNS			6	0	605.0	2,480	1,496	1,460	680.9	514.5	45.52	1,893	2,360
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	6	0	5,770	15,000	10,253	10,070	3,280	2,295	31.99	12,100	14,400
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	6	3	9.00	22.00	15.33	15.00	6.51	6.00	42.43	18.50	21.30
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	6	0	3,300	8,800	6,067	6,050	1,988	1,500	32.76	7,275	8,500
Vanadium, µg/l (T)	Livestock (HT)	100	100	6	6	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Zinc (T)	Primary Contact Ceremonial (HT)	7.4	25	6	0	0.07	0.67	0.44	0.51	0.23	0.13	51.53	0.60	0.65
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	5	1	0.26	0.50	0.40	0.43	0.12	0.08	29.42	0.50	0.50

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-3.5 Springs NSPG151, 162 Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Most Protective Standard (NN: Navajo Nation, HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)	Aquatic & Wildlife, chronic (NN)	0.087	NCNS	10	4	0.02	35.10	20.95	21.70	11.73	4.00	55.97	26.38	33.23
Aluminum (D)	Agric. Water, Livestock (HT)	5	5	10	5	19.80	34.60	25.02	23.10	5.90	3.30	23.58	26.40	32.96
Arsenic, µg/l (T)	Primary Contact Ceremonial (HT)	10	200	10	3	9.00	19.00	15.43	17.00	4.16	2.00	26.95	19.00	19.00
Arsenic, µg/l (D)	Aquatic & Wildlife, chronic (both)	150	NNS	8	3	11.00	19.00	15.40	16.00	3.05	2.00	19.80	17.00	18.60
Bicarbonate	NNS			10	5	882.0	1,260	1,084	1,080	137.4	60.00	12.67	1,140	1,236
Boron, µg/l	Agric. Water Supply (HT)	1,000 (T)	5,000 (D)	10	0	1,880	8,600	4,771	4,540	2,884	2,560	60.44	7,125	8,209
Cadmium, µg/l (T)	Primary Contact Ceremonial (HT)	5	50	10	9	4.30	4.30	4.30	4.30	N/A	N/A	N/A	4.30	4.30
Cadmium, µg/l (D)	Aquatic & Wildlife, chronic (both)	0.64	NNS	10	7	3.10	3.70	3.40	3.40	0.30	0.30	8.82	3.55	3.67
Calcium	NNS			10	0	359.0	449.0	410.7	413.0	24.03	11.50	5.85	420.8	441.8
Chloride	Aquatic & Wildlife (HT)	230	NCNS	10	0	140.0	460.0	265.9	245.5	119.7	85.00	45.01	325.0	451.0
Chromium, µg/l (T)	Livestock (both)	1000	1000	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Chromium, µg/l (D)	NNS			10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS	NCNS	10	0	6,210	11,600	8,786	8,765	2,098	2,095	23.88	10,578	11,555
Copper, µg/l (T)	Livestock (HT)	500	500	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Copper, µg/l (D)	Aquatic & Wildlife, chronic (both)	29	500	10	9	8.00	8.00	8.00	8.00	N/A	N/A	N/A	8.00	8.00
Fluoride	Primary Contact Ceremonial (HT)	4	NCNS	10	0	0.20	1.20	0.72	0.75	0.41	0.40	57.38	1.08	1.20
Iron (T)	Primary Contact Ceremonial (HT)	0.3	NCNS	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Iron (D)	NNS			10	8	0.07	0.08	0.08	0.08	0.01	0.01	9.43	0.08	0.08
Lead, µg/l (T)	Primary Contact Ceremonial (HT)	15	100	10	8	1.50	1.80	1.65	1.65	0.21	0.15	12.86	1.73	1.79
Lead, µg/l (D)	Aquatic & Wildlife, chronic (both)	11	NNS	10	7	1.40	1.50	1.47	1.50	0.06	0.00	3.94	1.50	1.50
Magnesium	NNS			10	0	786.0	1,440	1,115	1,195	241.8	205.0	21.68	1,278	1,404
Manganese (T)	Primary Contact Ceremonial (HT)	0.05	NCNS	10	2	0.06	3.24	1.59	1.85	1.25	1.17	78.57	2.52	3.08
Manganese (D)	NNS			10	1	0.05	3.24	1.39	1.68	1.25	1.25	90.22	2.36	3.02
Mercury, µg/l (T)	Aquatic & Wildlife, chronic (NN)	0.001	10 (HT)	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	Primary Contact Ceremonial (HT)	10	NCNS	10	0	36.60	51.10	44.00	43.60	4.85	3.95	11.02	47.58	50.43
Nitrite as N	Primary Contact Ceremonial (HT)	1.0	NCNS	10	3	0.02	0.11	0.05	0.02	0.04	0.00	79.49	0.10	0.11
NO3 + NO2	Livestock (NN)	0.132	0.132	10	0	36.60	51.20	43.98	43.60	4.91	3.95	11.16	47.58	50.53
pH	Livestock (both)	6.5 – 9.0	6.5 – 9.0	10	0	3.60	8.30	6.00	6.05	2.18	2.00	36.35	8.00	8.21
Selenium, µg/l (T)	Primary Contact Ceremonial (HT)	0.17	50	10	0	81.00	213.0	133.9	127.0	38.48	26.70	28.72	157.2	190.4
Sodium	NNS			10	0	392.0	1,390	840.3	764.5	446.6	371.5	53.15	1,255	1,363
Solids, Dissolved	Aquatic & Wildlife Habitat (HT)	500	NCNS	10	0	6,650	12,800	9,822	10,110	2,432	2,415	24.77	11,825	12,755
Solids, Suspended	Aquatic & Wildlife Habitat (NN)	80	NCNS	10	4	6.00	15.00	8.50	7.50	3.39	1.50	39.90	8.75	13.50
Sulfate	Aquatic & Wildlife Habitat (HT)	250	NCNS	10	0	4,170	7,760	5,883	5,850	1,446	1,500	24.58	7,300	7,598
Vanadium, µg/l (T)	Livestock (HT)	100	100	10	5	60.00	104.0	80.80	80.00	17.12	10.00	21.19	90.00	101.2
Vanadium, µg/l (D)	Agric. Water, Livestock (both)	100	100	9	5	32.00	90.00	65.75	70.50	25.77	15.00	39.20	83.25	88.65
Zinc (T)	Primary Contact Ceremonial (HT)	7.4	25	10	5	1.07	1.45	1.25	1.18	0.18	0.11	14.23	1.42	1.44
Zinc (D)	Aquatic & Wildlife, chronic (both)	0.38	NNS	9	3	0.02	1.50	1.02	1.10	0.53	0.22	51.99	1.35	1.48

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard, NNS: No Numeric Standard.

Source: PWCC 2012 et seq.

Table WR-3.6. Spring NSPG140 Long-term Water Quality Summary, 1981 - 2001 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		22	21	0.1	0.1	0.1	0.1	N/A	N/A	N/A	0.1	0.1
Arsenic, µg/l	Both	200 (T)		22	16	1.0	3.0	2.0	2.0	0.6	0.0	31.6	2.0	2.8
Bicarbonate	NCNS			28	0	38.0	429.6	214.2	218.4	120.7	108.1	56.3	324.5	406.7
Boron, µg/l	NN	5,000		28	2	100.0	620.0	292.8	245.0	136.6	50.0	46.7	372.0	526.0
Cadmium, µg/l	Both	50 (T)		22	20	19.0	20.0	19.5	19.5	0.7	0.5	3.6	19.8	20.0
Calcium	NCNS			28	0	96.0	654.0	389.8	407.0	127.3	51.6	32.7	454.0	538.7
Chloride	NCNS			28	0	18.0	126.0	55.9	51.5	27.9	11.5	49.9	59.3	114.4
Chromium, µg/l	Both	1000 (T)		22	22	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		24	0	1,810.0	8,760.0	4,897.5	4,245.0	1,828.2	900.0	37.3	6,065.0	8,375.5
Copper, µg/l	HT; NN	500 (T; D)		22	20	20.0	20.0	20.0	20.0	0.0	0.0	0.0	20.0	20.0
Fluoride	NCNS		2	28	0	0.2	1.1	0.7	0.7	0.2	0.2	33.7	0.9	0.9
Iron	NCNS			28	16	0.0	0.1	0.1	0.0	0.0	0.0	47.8	0.1	0.1
Lead, µg/l	Both	100 (T)		22	18	50.0	180.0	117.5	120.0	67.0	55.0	57.0	172.5	178.5
Magnesium	NCNS			28	0	121.0	850.0	406.1	372.0	188.6	109.6	46.4	493.8	766.3
Manganese	NCNS			28	10	0.0	1.1	0.2	0.1	0.3	0.1	138.2	0.2	0.9
Mercury, µg/l	HT	10 (T)		22	19	0.2	0.5	0.3	0.2	0.2	0.0	57.7	0.4	0.5
Nitrate as N	NCNS		400	27	6	0.0	6.5	2.5	1.8	2.3	1.7	91.7	4.6	6.2
Nitrite as N	NCNS		100	27	16	0.0	0.3	0.0	0.0	0.1	0.0	177.7	0.0	0.2
NO3 + NO2	NN	0.132		16	4	0.2	6.5	3.3	4.0	2.6	2.3	77.7	5.7	6.3
pH	Both	6.5 – 9.0		25	0	6.8	9.0	8.0	8.0	0.6	0.4	7.6	8.4	9.0
Selenium, µg/l	Both	50 (T)		22	15	1.0	8.0	4.0	4.0	2.8	2.0	69.2	6.0	7.4
Sodium	NCNS		1,000	28	0	118.0	836.0	371.6	341.0	163.7	93.5	44.1	441.3	667.6
Solids, Dissolved	NCNS		2,000	27	0	1,554.0	9,280.0	4,813.3	4,252.0	1,939.6	1,028.0	40.3	5,790.0	8,625.2
Solids, Suspended	NCNS			28	3	4.0	204.0	42.6	22.0	52.2	14.0	122.3	52.0	168.4
Sulfate			1,000	28	0	986.0	6,481.0	3,151.1	2,957.5	1,319.1	750.0	41.9	3,732.8	5,640.2
Vanadium, µg/l	HT; NN	100 (T; D)		22	21	10.0	10.0	10.0	10.0	N/A	N/A	N/A	10.0	10.0
Zinc	NCNS			23	19	0.0	0.0	0.0	0.0	0.0	0.0	38.5	0.0	0.0

Data source: PWCC 2012 et seq.

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et. al. 2008; Sigler and Kleehammer 2013.

Table WR-3.7. Spring NSPG151 Long-term Water Quality Summary, 2000 – 2011 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		4	3	0.1	0.1	0.1	0.1	N/A	N/A	N/A	0.1	0.1
Arsenic, µg/l	Both	200 (T)		1	0	14.0	14.0	14.0	14.0	N/A	N/A	N/A	14.0	14.0
Bicarbonate	NCNS			24	0	443.0	1,160.0	898.8	920.0	218.0	203.5	24.3	1,082.5	1,148.5
Boron, µg/l	NN	5,000		24	0	1,960.0	5,100.0	3,042.5	3,100.0	781.3	550.0	25.7	3,455.0	4,330.0
Cadmium, µg/l	Both	50 (T)		4	4	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NCNS			24	0	348.0	520.0	447.3	456.0	33.0	20.0	7.4	465.0	480.6
Chloride	NCNS			24	0	47.0	173.0	125.3	123.5	31.6	20.5	25.2	146.3	170.0
Chromium, µg/l	Both	1000 (T)		4	4	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		24	0	5,820.0	12,000.0	9,515.8	9,960.0	1,902.6	1,640.0	20.0	11,275.0	11,800.0
Copper, µg/l	HT; NN	500 (T; D)		4	2	8.0	30.0	19.0	19.0	15.6	11.0	81.9	24.5	28.9
Fluoride	NCNS		2	24	0	0.5	1.4	1.0	1.0	0.2	0.2	24.6	1.2	1.3
Iron	NCNS			24	23	0.1	0.1	0.1	0.1	N/A	N/A	N/A	0.1	0.1
Lead, µg/l	Both	100 (T)		3	3	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NCNS			24	0	753.0	1,550.0	1,190.4	1,270.0	253.2	170.0	21.3	1,400.0	1,477.0
Manganese	NCNS			24	9	0.0	0.4	0.1	0.1	0.1	0.0	114.9	0.1	0.3
Mercury, µg/l	HT	10 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate as N	NCNS		400	24	0	2.0	91.0	56.2	56.3	16.8	9.1	29.9	64.0	74.9
Nitrite as N	NCNS		100	24	5	0.0	1.4	0.1	0.0	0.3	0.0	261.6	0.1	0.3
NO3 + NO2	NN	0.132		24	0	2.0	91.0	56.3	56.3	16.9	9.1	29.9	65.1	74.9
pH	Both	6.5 – 9.0		24	0	7.1	8.3	7.8	7.8	0.2	0.2	3.2	8.0	8.2
Selenium, µg/l	Both	50 (T)		6	0	98.0	186.0	131.2	124.7	30.1	11.0	22.9	136.1	174.0
Sodium	NCNS		1,000	24	0	459.0	1450.0	1056.3	1100.0	299.5	255.0	28.4	1305.0	1,390.0
Solids, Dissolved	NCNS		2,000	24	0	7,050.0	14,200.0	11,275.8	11,850.0	2,215.8	1,600.0	19.7	13,225.0	14,040.0
Solids, Suspended	NCNS			24	7	6.0	36.0	19.5	18.0	10.2	8.0	52.6	24.0	36.0
Sulfate			1,000	24	0	4,850.00	8,960.00	6,955.83	7,125.00	1,232.77	1,035.00	17.72	7,795.00	8,699.50
Vanadium, µg/l	HT; NN	100 (T; D)		3	0	32.0	141.0	93.7	108.0	55.9	33.0	59.7	124.5	137.7
Zinc	NCNS			2	1	0.0	0.0	0.0	0.0	N/A	N/A	N/A	0.0	0.0

Data source: PWCC 2012 et seq.

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck, et al. 2008; Sigler and Kleehammer 2013.

Table WR-3.8 Spring NSPG 191 Water Quality Summary, 2003 – 2005 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic, µg/l	Both	200 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bicarbonate	NCNS			5	0	188.0	234.0	215.0	210.0	19.4	22.0	9.0	234.0	234.0
Boron, µg/l	NN	5,000		5	0	120.0	190.0	154.0	160.0	26.1	20.0	16.9	160.0	184.0
Cadmium, µg/l	Both	50 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Calcium	NCNS			5	0	163.0	226.0	190.8	184.0	29.0	21.0	15.2	216.0	224.0
Chloride	NCNS			5	0	14.0	35.0	21.6	19.0	7.9	2.0	36.7	21.0	32.2
Chromium, µg/l	Both	1000 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Conductivity	<1.5 x background (HT)	NCNS		5	0	1,150.00	1,690.00	1,420.00	1,410.00	194.94	70.00	13.73	1,480.00	1,648.00
Copper, µg/l	HT; NN	500 (T; D)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fluoride	NCNS		2	5	0	0.3	0.6	0.4	0.4	0.1	0.0	26.1	0.4	0.6
Iron	NCNS			5	5	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l	Both	100 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Magnesium	NCNS			5	0	45.6	69.7	56.5	56.6	8.9	4.4	15.7	58.5	67.5
Manganese	NCNS			5	3	0.0	0.0	0.0	0.0	0.0	0.0	41.6	0.0	0.0
Mercury, µg/l	HT	10 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate as N	NCNS		400	5	0	1.3	4.2	3.4	3.8	1.2	0.3	35.0	3.9	4.1
Nitrite as N	NCNS		100	5	3	0.0	0.1	0.0	0.0	0.0	0.0	94.3	0.0	0.0
NO3 + NO2	NN	0.132		5	0	1.3	4.2	3.4	3.9	1.2	0.2	35.0	3.9	4.1
pH	Both	6.5 – 9.0		5	0	7.2	8.0	7.8	7.9	0.3	0.1	4.1	7.9	8.0
Selenium, µg/l	Both	50 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sodium	NCNS		1,000	5	0	58.5	83.3	74.1	78.0	9.7	5.3	13.1	79.4	82.5
Solids, Dissolved	NCNS		2,000	5	0	940.00	1,390.00	1,148.00	1,170.00	164.98	100.00	14.37	1,170.00	1,346.00
Solids, Suspended	NCNS			5	4	48.0	48.0	48.0	48.0	N/A	N/A	N/A	48.0	48.0
Sulfate			1,000	5	0	510.0	810.0	644.0	660.0	111.9	80.0	17.4	660.0	780.0
Vanadium, µg/l	HT; NN	100 (T; D)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	NCNS			0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Data source: PWCC 2012 et seq.

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Table WR-3.9. Spring NSPG 147 Long-term Water Quality Summary, 1989 – 2011 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		12	8	0.1	0.2	0.1	0.1	0.1	0.0	55.9	0.1	0.2
Arsenic, µg/l	Both	200 (T)		10	7	2.0	13.0	6.0	3.0	6.1	1.0	101.4	8.0	12.0
Bicarbonate	NCNS			36	0	255.0	676.0	494.0	516.0	124.1	100.5	25.1	590.0	666.8
Boron, µg/l	NN	5,000		35	0	3,040.0	5,200.0	3,736.3	3,700.0	446.6	200.0	12.0	3,895.0	4,530.0
Cadmium, µg/l	Both	50 (T)		12	12	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	NCNS			35	0	289.0	483.0	412.4	413.0	33.9	15.0	8.2	432.0	456.3
Chloride	NCNS			36	0	51.0	250.0	159.9	159.5	48.2	20.0	30.1	188.5	231.0
Chromium, µg/l	Both	1000 (T)		12	12	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		36	0	6,800.0	13,100.0	9,198.3	9,305.0	1,279.7	760.0	13.9	9,895.0	10,750.0
Copper, µg/l	HT; NN	500 (T; D)		12	11	20.0	20.0	20.0	20.0	N/A	N/A	N/A	20.0	20.0
Fluoride	NCNS		2	36	0	0.3	2.0	0.6	0.5	0.3	0.1	46.8	0.6	0.8
Iron	NCNS			35	7	0.0	27.8	1.5	0.2	5.3	0.1	363.5	0.3	5.0
Lead, µg/l	Both	100 (T)		11	11	ND	ND	ND	ND	ND	ND	ND	ND	ND
Magnesium	NCNS			35	0	440.0	774.0	552.9	559.0	68.7	31.0	12.4	582.5	677.5
Manganese	NCNS			35	0	5.7	11.7	9.5	9.5	1.0	0.7	10.8	10.3	10.7
Mercury, µg/l	HT	10 (T)		9	9	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate as N	NCNS		400	34	0	3.5	119.0	25.3	19.9	22.9	9.1	90.7	28.7	62.8
Nitrite as N	NCNS		100	34	4	0.0	4.5	0.3	0.2	0.8	0.1	231.1	0.4	0.5
NO3 + NO2	NN	0.132		35	0	3.6	120.0	25.0	19.6	23.1	9.1	92.6	29.0	65.8
pH	Both	6.5 – 9.0		35	0	6.0	8.0	6.7	6.6	0.4	0.3	6.7	6.9	7.5
Selenium, µg/l	Both	50 (T)		10	2	5.0	68.0	16.9	9.5	21.0	2.0	124.5	12.0	50.5
Sodium	NCNS		1,000	35	0	971.0	2,060.0	1,356.0	1,340.0	214.2	80.0	15.8	1,427.5	1,669.0
Solids, Dissolved	NCNS		2,000	36	0	7,460.0	13,406.0	9,207.0	9,075.0	1,077.2	275.0	11.7	9,282.5	10,889.8
Solids, Suspended	NCNS			35	10	4.0	530.0	48.2	20.0	105.4	10.0	219.0	34.0	145.2
Sulfate			1,000	36	0	3,780.0	9,210.0	5,864.8	5,850.0	937.5	525.0	16.0	6,315.0	7,130.8
Vanadium, µg/l	HT; NN	100 (T; D)		12	12	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	NCNS			11	0	0.4	1.0	0.8	0.8	0.2	0.1	27.1	0.9	1.0

Data source: PWCC 2012 et seq.

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Table WR-3.10. Spring NSPG 92 Long-term Water Quality Summary, 1980 - 2010 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		18	16	0.1	0.1	0.1	0.1	0.0	0.0	12.9	0.1	0.1
Arsenic, µg/l	Both	200 (T)		16	13	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0
Bicarbonate	NCNS			33	0	250.7	964.0	572.4	627.0	198.9	136.0	34.7	716.0	875.4
Boron, µg/l	NN	5,000		32	3	60.0	470.0	181.5	180.0	80.5	40.0	44.3	220.0	304.2
Cadmium, µg/l	Both	50 (T)		19	17	10.0	20.0	15.0	15.0	7.1	5.0	47.1	17.5	19.5
Calcium	NCNS			33	0	83.0	407.0	268.0	273.0	87.4	44.0	32.6	317.0	384.6
Chloride	NCNS			33	0	12.0	123.0	62.0	60.0	26.7	20.0	43.1	82.0	100.1
Chromium, µg/l	Both	1000 (T)		20	20	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		29	0	1,390.00	7,000.00	3,904.48	3,980.00	1,202.85	720.00	30.81	4,460.00	5,862.00
Copper, µg/l	HT; NN	500 (T; D)		20	14	10.0	30.0	19.5	20.0	8.3	8.5	42.8	25.3	29.3
Fluoride	NCNS		2	33	0	0.7	2.7	1.0	0.9	0.3	0.1	34.7	1.0	1.1
Iron	NCNS			33	24	0.0	0.3	0.1	0.1	0.1	0.0	103.0	0.1	0.2
Lead, µg/l	Both	100 (T)		19	16	130.0	240.0	170.0	140.0	60.8	10.0	35.8	190.0	230.0
Magnesium	NCNS			33	0	89.0	453.0	271.0	280.0	96.2	48.0	35.5	323.0	414.0
Manganese	NCNS			33	3	0.0	1.7	0.3	0.2	0.4	0.1	127.3	0.4	1.3
Mercury, µg/l	HT	10 (T)		17	15	0.3	3.0	1.7	1.7	1.9	1.4	115.7	2.3	2.9
Nitrate as N	NCNS		400	32	6	0.0	28.9	2.5	0.3	5.9	0.3	236.3	1.7	7.7
Nitrite as N	NCNS		100	32	24	0.0	0.0	0.0	0.0	0.0	0.0	120.6	0.0	0.0
NO3 + NO2	NN	0.132		22	5	0.0	28.9	2.5	0.2	7.0	0.1	284.9	1.0	11.0
pH	Both	6.5 – 9.0		30	0	7.3	8.5	8.0	8.0	0.3	0.2	3.8	8.2	8.4
Selenium, µg/l	Both	50 (T)		18	16	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0
Sodium	NCNS		1,000	33	0	115.0	675.0	398.2	392.0	130.6	78.0	32.8	482.0	614.2
Solids, Dissolved	NCNS		2,000	32	0	1,018.00	6,140.00	3,684.78	3,640.00	1,241.12	806.50	33.68	4,535.00	5,700.15
Solids, Suspended	NCNS			33	9	2.00	531.00	59.58	16.00	115.99	8.00	194.67	44.00	238.85
Sulfate			1,000	33	0	591.00	3,730.00	2,055.55	2,027.00	695.82	297.00	33.85	2,400.00	3,150.00
Vanadium, µg/l	HT; NN	100 (T; D)		20	19	20.0	20.0	20.0	20.0	N/A	N/A	N/A	20.0	20.0
Zinc	NCNS			19	15	0.0	0.0	0.0	0.0	0.0	0.0	40.8	0.0	0.0

Data source: PWCC 2012 et seq.

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Table WR-3.11 Spring NSPG 91 Long-term Water Quality Summary, 1980 - 2011 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		22	19	0.1	1.1	0.4	0.1	0.6	0.0	147.7	0.6	1.0
Arsenic, µg/l	Both	200 (T)		20	20	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bicarbonate	NCNS			35	0	286.0	552.9	353.5	351.0	40.9	14.0	11.6	357.0	397.5
Boron, µg/l	NN	5,000		34	1	40.0	431.0	115.0	110.0	60.6	10.0	52.6	110.0	152.0
Cadmium, µg/l	Both	50 (T)		23	21	10.0	25.0	17.5	17.5	10.6	7.5	60.6	21.3	24.3
Calcium	NCNS			35	0	131.0	319.0	201.8	200.0	31.7	12.0	15.7	209.5	260.0
Chloride	NCNS			35	0	6.0	46.9	9.7	7.8	8.2	0.8	85.2	8.5	22.0
Chromium, µg/l	Both	1000 (T)		23	23	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		33	0	1,390.00	3,370.00	1,731.94	1,630.00	403.20	70.00	23.28	1,690.00	2,484.00
Copper, µg/l	HT; NN	500 (T; D)		23	22	4.0	4.0	4.0	4.0	N/A	N/A	N/A	4.0	4.0
Fluoride	NCNS		2	35	0	0.8	2.2	1.9	2.0	0.3	0.2	17.2	2.1	2.2
Iron	NCNS			35	8	0.0	9.8	4.5	3.8	3.6	3.4	80.3	8.1	9.4
Lead, µg/l	Both	100 (T)		22	19	20.0	150.0	86.7	90.0	65.1	60.0	75.1	120.0	144.0
Magnesium	NCNS			35	0	98.0	313.0	129.5	120.0	42.9	7.0	33.1	125.0	189.0
Manganese	NCNS			35	4	0.0	0.5	0.2	0.2	0.1	0.0	39.1	0.2	0.2
Mercury, µg/l	HT	10 (T)		19	18	0.2	0.2	0.2	0.2	N/A	N/A	N/A	0.2	0.2
Nitrate as N	NCNS		400	35	14	0.0	1.4	0.2	0.1	0.3	0.0	170.0	0.1	0.5
Nitrite as N	NCNS		100	35	28	0.0	0.0	0.0	0.0	0.0	0.0	81.6	0.0	0.0
NO3 + NO2	NN	0.132		27	9	0.0	1.4	0.1	0.1	0.3	0.0	222.1	0.1	0.4
pH	Both	6.5 – 9.0		33	0	6.7	8.6	7.8	7.9	0.5	0.3	5.8	8.1	8.3
Selenium, µg/l	Both	50 (T)		20	19	20.0	20.0	20.0	20.0	N/A	N/A	N/A	20.0	20.0
Sodium	NCNS		1,000	35	0	31.0	250.0	47.8	37.9	40.8	1.9	85.3	39.8	91.2
Solids, Dissolved	NCNS		2,000	35	0	1,087.00	4,137.00	1,479.09	1,340.00	555.90	48.00	37.58	1,395.00	2,174.20
Solids, Suspended	NCNS			35	2	2.00	5,325.00	198.72	20.00	922.13	10.00	464.04	36.00	225.20
Sulfate			1,000	35	0	558.00	2,250.00	829.86	737.00	352.70	27.00	42.50	775.00	1,420.00
Vanadium, µg/l	HT; NN	100 (T; D)		22	21	10.0	10.0	10.0	10.0	N/A	N/A	N/A	10.0	10.0
Zinc	NCNS			21	19	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01

Data source: PWCC 2012 et seq.

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Table WR-3.12. Spring NSPG 22 Water Quality Summary, 2005 – 2011 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		3	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic, µg/l	Both	200 (T)		1	1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bicarbonate	NCNS			11	0	744.0	1160.0	988.1	992.0	166.3	148.0	16.8	1135.0	1,160.0
Boron, µg/l	NN	5,000		11	0	390.0	560.0	465.5	470.0	62.3	50.0	13.4	505.0	560.0
Cadmium, µg/l	Both	50 (T)		3	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	NCNS			11	0	387.0	482.0	443.5	451.0	31.6	18.0	7.1	466.5	479.0
Chloride	NCNS			11	0	44.0	58.0	48.1	47.0	4.2	3.0	8.6	50.0	54.5
Chromium, µg/l	Both	1000 (T)		3	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		11	0	8,420.0	9,460.0	8,915.5	8,880.0	359.0	360.0	4.0	9,190.0	9,405.0
Copper, µg/l	HT; NN	500 (T; D)		3	2	20.0	20.0	20.0	20.0	N/A	N/A	N/A	20.0	20.0
Fluoride	NCNS		2	11	0	0.1	0.5	0.4	0.4	0.1	0.0	31.8	0.4	0.5
Iron	NCNS			11	8	0.0	0.2	0.1	0.1	0.1	0.1	77.7	0.2	0.2
Lead, µg/l	Both	100 (T)		2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Magnesium	NCNS			11	0	372.0	456.0	415.1	413.0	25.8	12.0	6.2	432.5	451.0
Manganese	NCNS			11	2	0.0	2.8	1.0	1.0	1.0	0.9	97.0	1.7	2.4
Mercury, µg/l	HT	10 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate as N	NCNS		400	11	0	0.0	3.5	1.4	1.7	1.1	0.8	82.7	2.1	2.9
Nitrite as N	NCNS		100	11	5	0.0	0.1	0.0	0.0	0.0	0.0	58.1	0.0	0.1
NO3 + NO2	NN	0.132		11	0	0.0	3.5	1.4	1.7	1.1	0.8	81.9	2.2	2.9
pH	Both	6.5 – 9.0		11	0	7.7	8.4	8.1	8.1	0.2	0.2	2.9	8.3	8.4
Selenium, µg/l	Both	50 (T)		0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sodium	NCNS		1,000	11	0	1,400.00	1,870.00	1,667.27	1,630.00	138.93	50.00	8.33	1,765.00	1,865.00
Solids, Dissolved	NCNS		2,000	11	0	8,170.0	9,660.0	8,808.2	8,810.0	402.2	180.0	4.6	8,930.0	9,430.0
Solids, Suspended	NCNS			11	5	7.0	184.0	41.8	15.0	69.9	7.0	167.0	20.5	143.5
Sulfate			1,000	11	0	4,400.0	5,900.0	5,222.7	5,340.0	449.4	260.0	8.6	5,510.0	5,775.0
Vanadium, µg/l	HT; NN	100 (T; D)		2	1	40.0	40.0	40.0	40.0	N/A	N/A	N/A	40.0	40.0
Zinc	NCNS			2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND

Data source: PWCC 2012 et seq.

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

This page intentionally left blank

Appendix WR-4

Alluvial Groundwater Quality Characterizations PWCC Leasehold

This page intentionally left blank

Appendix WR-4. Alluvial Groundwater Characteristics, PWCC Leasehold

Alluvial groundwater monitoring locations on the leasehold are depicted here in **Figure WR-4.1**. Alluvial groundwater levels on the leasehold are summarized here in **Tables WR-4.1** and **WR-4.2**.

Previously dropping alluvial water levels noted along Coal Mine Wash during earlier years generally have been reversed in 2013 data, with rise of 1.2 to 1.5 feet noted at four of the seven wells along the wash (ALUV17, 19, 80R, 83, 193, 197, and 200). Declines at well ALUV72 continue a trend noted since the severe drought in 2009. That well is located adjacent to the N9 mining area, and may undergo drawdown due to pit inflows. However, water pumped out of the N9 pit is transferred to nearby ponds which may seep back into Yellow Water Canyon. PWCC states that there has been no noticeable reduction in baseflow along the wash between wells ALUV71 upstream and ALUV72 downstream past the mining area (see **Figure WR-4.1**).

Water levels at well ALUV93 (downstream on Moenkopi Wash) show mixed trends over time. That well is believed to be unaffected by mining activity, and fluctuations there likely result from climate effects and water withdrawals by vegetation (PWCC 2014). A mix of water level rises and declines can also be seen in the data for ALUV87, which is located on Moenkopi Wash well upstream of the mine areas (**Table WR-4.1** and **Figure WR-4.1**). In the year 2012, eight wells show rising water levels compared to data from 2011, whereas in 2013, 23 wells indicated rising water levels compared to the 2012 data. These 23 sites are distributed across the major washes, with six sites in Coal Mine Wash, four in Yellow Water Canyon, three along Moenkopi Wash, two in Red Peak Valley Wash, five along Dinnebito Wash, and the other three in smaller tributaries. On the basis of these widespread fluctuations, the 2013 trends have been taken to reflect climatic variations with the drainages, rather than inflows from nearby mining areas or the Wepo Formation (PWCC 2014).

Recent groundwater quality data are summarized here for alluvial wells in **Appendix WR-4**, **Tables WR-4.3** through **WR-4.12**. **Tables WR-4.3** through **WR-4.8** indicate data results for recent (2010-2014 sampling. **Tables WR-4.9** through **WR-4.12** show data results from long-term monitoring, upstream and downstream of the mine areas.

In the Yellow Water Canyon area, alluvial water is a mixed sulfate type, with total dissolved solids (TDS) concentrations generally from about 2,900 to 5,700 milligrams per liter (mg/L). Most trace element concentrations are detected at low levels, or are below laboratory detection limits. In one exception, boron concentrations range from about 230 to 380 µg/L. Although surface water quality standards for livestock uses do not actually apply to alluvial groundwater, sampling results have been compared to livestock standards. No exceedances of livestock standards occur in the recent data.

Along Coal Mine Wash, alluvial groundwater quality also consistently meets surface water criteria for livestock use. Boron concentrations range from 90 to 480 µg/L, and vanadium concentrations were occasionally on the order of 30 to 60 µg/L at sites ALUV193, ALUV83, and ALUV197. Samples reflect a mixed sulfate type, but bicarbonate concentrations are somewhat higher than in other water quality results.

Alluvial groundwater along Moenkopi Wash also consistently meets surface water criteria for livestock use. At Site ALUV87, which is well upstream of the mine areas, groundwater is generally a magnesium-sodium sulfate type with TDS concentrations ranging from 2,400 to 9,900 mg/L in recent samples. Bicarbonate concentrations range from about 320 to 680 mg/L, while sulfate concentrations range from 1,470 to 6,300 mg/L. Reaction (pH) ranges from 7.9 to 8.2 standard units. Most trace element concentrations are detected at low levels, or are below laboratory detection limits. In one exception, boron concentrations range from about 80 to 240 µg/L.

Downstream on Moenkopi Wash, ALUV93 is a sodium sulfate type. Groundwater at this site is more highly mineralized than at other locations, probably due to its location on a higher, greasewood-dominated terrace. Total dissolved solids at ALUV93 range from 9,770 to 24,700 mg/L. It is likely that the saline/alkaline terrace deposit and the accumulation of salts by the greasewood are reflected in the water chemistry at ALUV93. There are no hydrologically-connected mining activities in the locale. Nearby but downstream at ALUV95, groundwater ranges from a mixed bicarbonate to a mixed sulfate type and TDS ranges from 400 to 3,290 mg/L.

Alluvial groundwater quality along Reed Valley Wash is generally similar to that along Coal Mine and Moenkopi washes, being dominantly a mixed sulfate type with TDS ranging from 1,260 to 9,150 mg/L. The lower concentrations of most constituents occur downstream at Site ALUV165. In the Red Peak Valley/Yucca Flat/Sagebrush Wash tributaries to Moenkopi Wash, Sites ALUV104, 105, and 106 have a range of varying water types, from calcium-bicarbonate to mixed sulfate. Sulfates at those wells range from 210 to 1,140 mg/L and bicarbonates range from 193 to 354 mg/L. Other data from these tributaries are more consistent with overall Moenkopi Wash data, with mixed sulfate water types and TDS ranging from 3,820 to 6,550 mg/L. In these tributaries, alluvial groundwater quality also consistently meets surface water criteria for livestock use.

Along Dinnebito Wash, alluvial groundwater quality is a mixed sulfate or calcium sulfate type. Although surface water quality standards for livestock uses do not actually apply to alluvial groundwater, there are no exceedances of surface water criteria for livestock in the alluvial groundwater along Dinnebito Wash. Upstream water quality at Site ALUV108R is a calcium sulfate or mixed sulfate type, with sulfate concentrations ranging from 2,550 to 3,160 mg/L. TDS concentrations range from 4,380 to 4,990 mg/L and bicarbonate concentrations range from about 290 to 430 mg/L. Boron concentrations at ALUV108R range from 90 to 150 µg/L, and other trace element are either detected at low concentrations or are below laboratory detection limits. At Site ALUV201, the farthest downstream alluvial well, is a mixed type or calcium sulfate type. Sulfate concentrations range from 700 to 820 mg/L, and bicarbonate values range from about 325 to 390 mg/L. Concentrations for TDS range from 1,380 to 1,510 mg/L, showing generally improving alluvial groundwater quality downstream. Boron concentrations range from 70 to 130 µg/L, and other trace element are either detected at low concentrations or are below laboratory detection limits.

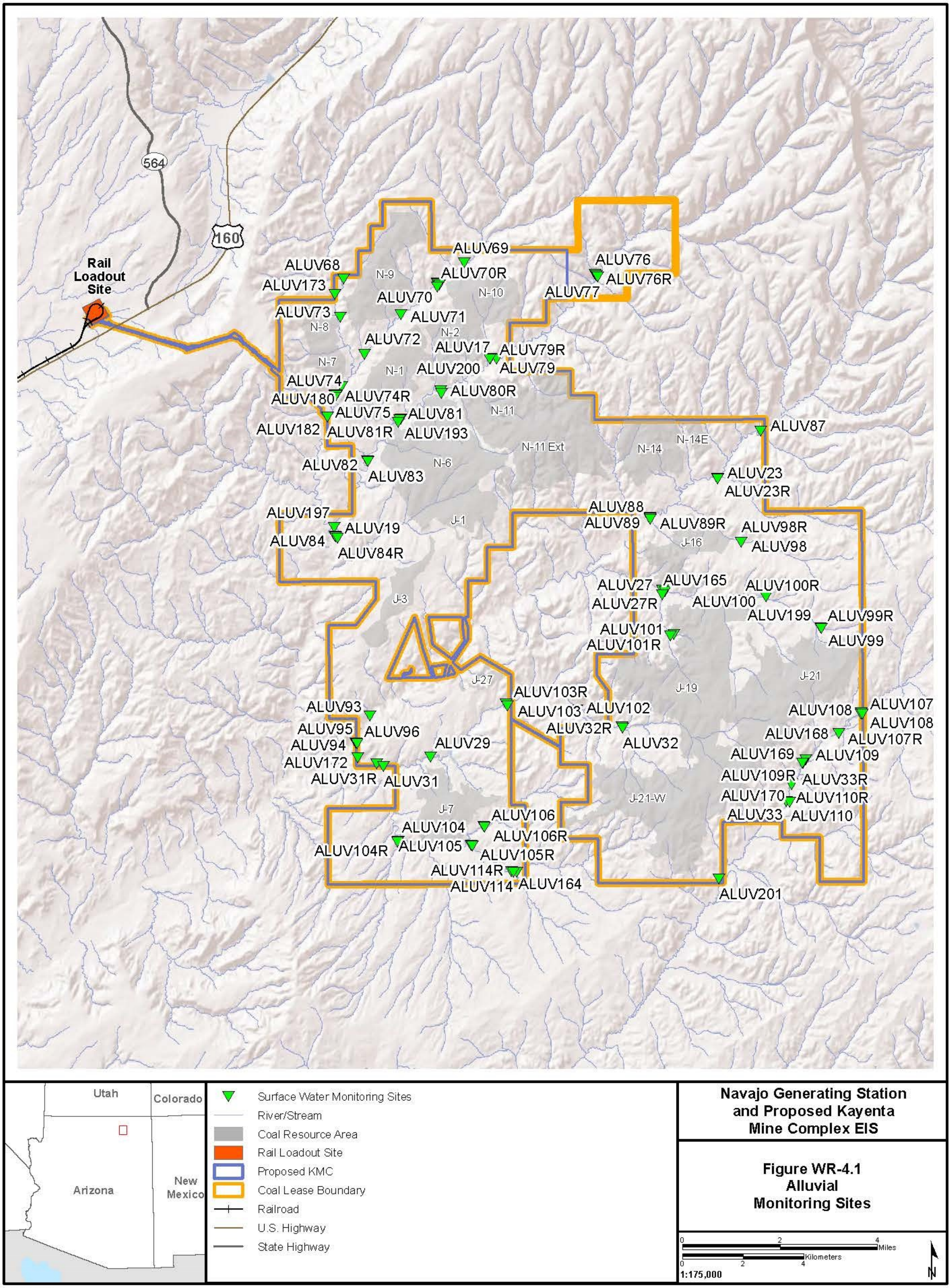


Figure WR-4.1
Alluvial
Monitoring Sites

This page intentionally left blank

Table WR-4.1 Alluvial Well Water Level Ranges for Select Periods

	Baseline Period		Affected Periods … [a]														2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	1980-1/84		01/80-01/88 [b]		01/88-01/95 [c]		01/95-01/13		2007	2008	2009	2010	2011	2012	2013	2014	Versus	Versus	Versus	Versus	Versus	Versus	Versus	Versus	Versus	Versus
Well Site	Min	Max	Min	Max	Min	Max	Min	Max	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ALUV13R	-	-	-	-	22.5	28.9	25.7	30.1	28.4	27.7	29.1	29.6	28.6	30.1	30.0	29.6	---	(0.2)	0.6	(0.7)	1.3	0.5	(1.0)	1.5	(0.1)	(0.4)
ALUV17	-	-	5.0	7.4	5.4	8.0	5.1	8.9	6.8-7.3	5.1-5.6	5.2-6.6	6.4-7.5	7.5-7.9	7.7-8.4	7.4-8.2	7.2-7.8	(1.4)	1.1	0.5	(1.7)	1.0	0.9	0.4	0.5	(0.2)	(0.4)
ALUV19	-	-	5.6	9.4	6.2	9.6	7.0	Dry	13.5-13.6	11.4-11.5	9.7-10.3	11.8-12.0	11.7-12.8	13.6-14.8	13.4-13.6	10.5-10.6	---	(0.3)	(2.6)	(2.1)	(1.2)	1.7	0.8	2.0	(1.2)	(3.0)
ALUV23R	-	-	-	-	19.2	Dry	Dry		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	---	---	---	---	---	---	---	---	---	---
ALUV29	-	-	0.4	5.3	0.4	7.2	0.0	7.9	0.0	0.2	2.4	0.0	0.0	0.1	0.0	0.2	(1.0)	(0.6)	(0.6)	0.2	2.2	(2.4)	---	(0.1)	(0.1)	0.2
ALUV31R	Site is idled																(1.7)	(2.0)	(4.8)	(6.2)	(2.5)	8.1	3.4	1.3		
ALUV69	-	-	4.6	10.0	6.0	10.8	8.3	13.2	11.8	10.1	11.6	11.2	12.4	13.2	12.6	12.9	---	0.4	0.9	(1.7)	1.5	(0.4)	1.2	0.8	(0.6)	0.3
ALUV71	-	-	14.6	16.6	15.6	16.9	15.4	18.3	15.4	15.7	16.6	17.5	18.1	18.3	18.0	18.0	---	(0.7)	(0.9)	0.3	0.9	0.9	0.6	0.2	(0.3)	---
ALUV72	-	-	11.6	13.3	9.2	13.5	9.6	13.6	10.4	9.6	10.1	10.1	12.1	13.6	13.7	14.1 **	---	(0.1)	(1.5)	(0.8)	0.5	---	2.0	1.5	0.1	0.4
ALUV80R	-	-	-	-	8.9	11.7	10.2	12.9	10.4-10.6	10.2-10.3	10.5-10.6	10.3	10.4-10.6	10.7-11.0	10.8-11.0	11.1-11.4	0.3	(2.0)	0.2	(0.3)	0.3	(0.3)	0.3	0.4	---	0.4
ALUV83	-	-	0.9	3.3	1.0	3.4	-3.4	3.5	-0.7/0.8	-3.0/-3.4	-1.3/0.5	-2.8/-0.8	-0.7/0.5	-0.7/1.4	-2.7/-0.1	-1.7/-0.9	1.3	1.0	(1.3)	(3.8)	3.4	(1.3)	1.3	0.9	(1.5)	(0.8)
ALUV87	14.2	22.5	14.2	22.9	17.8	23.1	17.3	24.1	20.3-21.7	17.3-19.4	18.8-20.2	19.5-22.2	19.5-22.0	22.4	20.9	23.7	(1.2)	0.5	0.5	(2.3)	0.8	2.0	(0.2)	0.4	(1.5)	3.7
ALUV89R	-	-	-	-	2.5	5.0	-0.2	6.3	1.7-4.3	0.5-1.1	1.0-1.7	0.8-1.2	-0.2/0.1	1.6	0.7	1.8	0.8	0.6	1.2	(3.2)	0.6	(0.5)	(1.1)	1.5	(0.9)	1.1
ALUV93	-	-	25.2	29.1	25.9	29.8	26.0	39.6	39.4	38.7	38.0	37.9	36.6	36.6	36.8	36.1	(0.6)	1.6	(0.2)	(0.7)	(0.7)	(0.1)	(1.3)	---	0.2	(0.7)
ALUV95	-	-	3.0	4.9	3.1	5.3	3.7	8.7	8.6	7.4-8.1	7.7	7.3	7.4	7.1	6.3	6.6	0.3	0.9	---	(0.5)	(0.4)	(0.4)	0.1	(0.3)	(0.8)	0.3
ALUV98R	-	-	-	-	9.6	14.3	11.6	16.3	14.9	13.3	15.2	13.4	14.1	14.7	14.0	15.5	(2.2)	0.3	1.5	(1.6)	1.9	(1.8)	0.7	0.6	(0.7)	1.5
ALUV99R	Site is idled																(1.4)	1.7	(3.6)	(3.0)	2.5	(1.4)	2.8	2.0		
ALUV101R	-	-	-	-	Dry		Dry		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	---	---	---	---	---	---	---	---	---	---
ALUV104R [d]	Site is idled																(0.4)	(4.4)	5.5	(3.0)	3.3	(0.7)	1.3	---		
ALUV105R	Site is idled																(0.8)	0.5	0.1	(0.7)	0.9	---	(0.4)	(0.1)		
ALUV106R	-	-	-	-	4.6	Dry	6.7	Dry	7.4-8.1	6.8-7.9	7.5-Dry	5.1-Dry	Dry	Dry	Dry	Dry	(0.3)	0.3	(0.2)	(0.3)	0.4	---	---	---	---	---
ALUV108R	-	-	-	-	7.1	11.0	8.8	15.1	12.4	13.3	14.9	14.3	15.1	15.0	13.8	16.0 **	(0.8)	(1.1)	0.1	0.9	1.6	(0.6)	0.8	(0.1)	(1.2)	2.2
ALUV165	-	-	-	-	20.3	28.7	27.2	33.0	33.0	31.4	32.1	30.8	31.2	31.2	30.3	29.2	(0.9)	1.0	0.5	(1.6)	0.7	(1.3)	0.4	---	(0.9)	(1.1)
ALUV168	-	-	-	-	(-)0.4	1.4	0.6	2.8	2.7	2.4	2.8	2.6	2.5	2.4	2.2	2.4	0.2	(0.2)	0.3	(0.3)	0.4	(0.2)	(0.1)	(0.1)	(0.2)	0.2
ALUV169	-	-	-	-	7.2	9.0	5.5	10.2	8.4	8.3	9.6	9.6	10.2	9.7	8.9	10.0	(1.6)	1.2	(0.3)	(0.1)	1.3	---	0.6	(0.5)	(0.8)	1.1
ALUV170	-	-	-	-	4.5	5.8	3.4	7.0	5.0-5.7	3.5-3.6	3.4-4.5	4.0-4.2	4.2-5.0	4.9-5.9	3.7-4.6	3.0-3.8	(1.3)	0.1	0.1	(2.1)	0.9	(0.3)	0.8	0.9	(1.3)	(0.8)
ALUV172	-	-	-	-	13.1	14.1	10.0	21.4	15.0	11.0	10.0	13.2-14.2	14.9	15.6	13.6	13.0	(1.8)	(1.7)	(2.3)	(4.0)	(1.0)	4.2	0.7	0.7	(2.0)	(0.6)
ALUV181	-	-	-	-	11.8	16.8	14.7	20.6	16.5	14.7	15.2	18.6	18.1	20.4	20.3	20.8 **	---	0.7	(1.4)	(1.8)	0.5	3.4	(0.5)	2.3	(0.1)	0.5
ALUV182	-	-	-	-	13.6	17.8	16.7	19.4	17.9	16.7	18.1	18.2	18.8	18.3	18.3	18.5	(0.8)	(2.3)	2.8	(1.2)	1.4	0.1	0.6	(0.5)	---	0.2
ALUV193	-	-	-	-	10.9	12.4	9.8	15.5	13.3-14.7	12.9-13.5	13.6-14.0	13.2-13.6	13.6-14.3	13.9-15.5	13.1-14.3	13.0-13.7	1.3	0.7	0.7	(1.2)	0.5	(0.4)	0.7	1.2	(1.2)	(0.6)
ALUV197	-	-	-	-	10.2	13.2	11.8	24.9	18.0-18.1	16.2-16.4	14.3-14.8	16.9-17.3	16.7-17.7	18.7-19.8	17.9-18.5	15.1-15.2	(1.7)	(0.8)	(2.3)	(1.7)	(1.6)	2.5	0.4	2.1	(1.3)	(3.3)
ALUV199	-	-	-	-	13.5	17.2	12.5	18.8	16.8	13.7	15.2	14.7	14.2	15.0	14.6	13.8	(0.8)	(0.2)	0.3	(3.1)	1.5	(0.5)	(0.5)	0.8	(0.4)	(0.8)
ALUV200	-	-	-	-	4.1	5.9	3.0	6.4	4.8-5.4	3.0-4.3	4.1-4.8	4.7-5.4	5.4-5.7	5.6-6.2	5.4-6.1	5.1-5.7	(0.9)	0.6	0.5	(1.1)	0.5	0.6	0.3	0.5	(0.1)	(0.4)
ALUV201	-	-	-	-	-	-	27.3	28.5	-	-	-	27.7-28.0	27.8-28.5	27.3-28.2	27.0-28.0	27.4	---	---	---	---	---	---	0.5	(0.3)	(0.2)	(0.6)
SAGEBRUSH	Site is idled																(0.8)	2.6	(1.9)	0.6	2.1	---	(2.7)	2.7		

Source: PWCC 2014

All values given are in feet below ground surface.

0.3 Water level deeper than in previous year

(1.1) Water level shallower than in previous year

--- No change in water level over previous year

* Historic minimum water level for these wells

** Historic maximum water level for these wells

	2005 Versus 2004	2006 Versus 2005	2007 Versus 2006	2008 Versus 2007	2009 Versus 2008	2010 Versus 2009	2011 Versus 2010	2012 Versus 2011	2013 Versus 2012	2014 Versus 2013
Idled	---	---	---	---	---	---	---	---	5	5
Deeper	6	18	17	4	26	11	22	21	2	13
Shallower	20	14	14	28	6	16	9	8	23	13
No change	8	2	3	2	2	8	4	6	5	4
Total	34	34	34	34	34	35	35	35	35	35
Dry	2	3	2	2	2	2	3	3	3	3

Notes:

[a] Refer to Tables 1-6 and Figure 1, Chapter 18, AZ-0001E Permit for information on affected vs. unaffected periods.

[b] True baseline data exists only for wells 23, 87, 88, and 102. The date range 1/84-1/88 is an interim period of potential mining influence between baseline data collection at these four wells, and installation of a number of replacement monitoring wells in 1988.

[c] The date range 1/88-1/95 is offered as a period of comparison for these wells with those for which baseline data exist.

[d] This well was overtopped by flooding numerous times in 2004 and 2005, and finally destroyed by flood of 8/8/05. New well installed near original site on 11/20/06.

This page intentionally left blank

Table WR-4.2 Alluvial Wells with No Baseline Water Level Data

Well Site	1/80-1/88 Water Level		1/88-1/95 Water Level		Historic Drawdown Compared to 1/88-1/95 Levels [a]		2013 Drawdown Compared to 1/88-1/95 Levels (ft)	Maximum Predicted Drawdowns (ft) [b]	Ponds in near Vicinity
	Range (ft)	Fluctuation (ft)	Range (ft)	Fluctuation (ft)	Range (ft)	Overage (ft)			
ALUV13R	---	---	22.5-28.9	6.4	25.7-30.1	1.2	1.1	36	None
ALUV17	5.0-7.4	2.4	5.4-8.0	2.6	5.1-8.9	0.9	0.2	53	N10-A1, N11-E
ALUV19	5.6-9.4	3.8	6.2-9.6	3.4	7.0-16.9 (Dry)	7.3	4.0	32	None
ALUV23R	---	---	19.2-19.5	0.3	19.5 (Dry)	0.0	Within	53	N14-H
ALUV29	0.4-5.3	4.9	0.4-7.2	6.8	0.0-7.9	0.7	Within	25	J7-A, J7-DAM
ALUV69	4.6-10.0	5.4	6.0-10.8	4.8	8.3-13.2	2.4	1.8	43	None
ALUV71	14.6-16.6	2	15.6-16.9	1.3	15.4-18.3	1.4	1.1	28	None
ALUV72	11.6-13.3	1.7	9.2-13.5	4.3	9.6-13.6	0.1	0.2	54	N9-E
ALUV80R	---	---	8.9-11.7	2.8	10.2-12.9	1.2	Within	54	N10-B1
ALUV83	0.9-3.3	2.4	1.0-3.4	2.4	(-)3.4-3.5	0.1	Within	40	None
ALUV89R	---	---	2.5-5.0	2.5	(-)0.2-6.3	1.3	Within	61	J16-F,G
ALUV93	25.2-29.1	3.9	25.9-29.8	3.9	26.0-39.6	9.8	7.0	23	None
ALUV95	3.0-4.9	1.9	3.1-5.3	2.2	3.7-8.7	3.4	1.0	20	None
ALUV98R	---	---	9.6-14.3	4.7	11.6-16.3	2.0	Within	57	J28-B,C,D
ALUV99R	Site is idled								
ALUV101R	---	---	Dry	0.0	19.0 (Dry)	0.0	Within	65	None
ALUV104R	Site is idled								
ALUV105R	Site is idled								
ALUV106R	---	---	4.6-8.3	3.7	6.7-8.3 (Dry)	0.0	Within	22	None
ALUV108R	---	---	7.1-11.0	3.9	8.8-15.1	4.1	2.8	33	None
ALUV165	---	---	20.3-28.7	8.4	27.2-33.0	4.3	1.6	65	J16-L
ALUV168	---	---	-0.4-1.4	1.8	0.6-2.8	1.4	0.8	34	J21-A
ALUV169	---	---	7.2-9.0	1.8	5.5-10.2	1.2	Within	36	J21-D,E
ALUV170	---	---	4.5-5.8	1.3	3.4-7.0	1.2	Within	34	J21-F,F1
ALUV172	---	---	13.1-14.1	1.0	10.0-21.4	7.3	Within	19	None
ALUV181	---	---	11.8-16.8	5.0	14.7-20.6	3.8	3.5	32	None
ALUV182	---	---	13.6-17.8	4.2	16.7-19.4	1.6	0.5	32	KM-A3
ALUV193	---	---	10.9-12.4	1.5	9.8-15.5	3.1	1.9	46	N6-H
ALUV197	---	---	10.2-13.2	3.0	11.8-24.9	11.7	5.3	32	None
ALUV199	---	---	13.5-17.2	3.7	12.5-18.8	1.6	Within	62	J28-G
ALUV200	---	---	4.1-5.9	1.8	3.0-6.4	0.5	0.2	53	N10-A1, N11-E
ALUV201	---	---	---	---	27.3-28.5	[d]	[d]	n/a	J21-I

Notes:

[a] Pre-2013 post-1988-1/95 maximum drawdown compared with 1/88-1/95 maximum (1980-1/88 maximum for older Coal Mine Wash wells).

[b] Maximum predicted drawdowns are taken from Table 8, Chapter 18, AZ-0001E PAP, as revised

[c] These wells are typically dry, therefore maximum predicted drawdowns have been set equal to maximum saturated thickness evidenced during the entire period of record.

[d] Well 201 was installed in 2012, and therefore has no historic period of record.

Source: PWCC 2014.

This page intentionally left blank

TableWR-4.3 Yellow Water Canyon Alluvial Wells (13R, 69, 71, 72, 181, 182) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		30	28	0.04	0.07	0.06	0.055	0.02	0.02	38.57	0.0625	0.07
Arsenic, µg/l	Both	200 (T)		30	27	0.9	5	2.37	1.2	2.29	0.30	96.57	3.1	4.62
Bicarbonate	NCNS			30	0	311	760	490.27	423.5	147.20	67.00	30.03	637.75	731.4
Boron, µg/l	NN	5,000		30	0	230	380	291.33	280	39.80	20.00	13.66	315	365.5
Cadmium, µg/l	Both	50 (T)		30	23	0.7	1.4	0.87	0.8	0.26	0.10	29.42	0.9	1.28
Calcium	NCNS			30	0	258	503	378.80	384.5	60.66	43.5	16.01	410.75	473.0
Chloride	NCNS			30	0	38	119	53.50	45.5	21.51	4.50	40.21	50.75	109.1
Chromium, µg/l	Both	1000 (T)		30	30	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		30	0	3,100.0	5,300.0	4,239.3	4,195.0	699.2	625.0	16.5	4,850.0	5,260
Copper, µg/l	HT; NN	500 (T; D)		30	29	20	20	20.00	20	N/A	N/A	N/A	20	20.00
Fluoride	NCNS		2	30	0	0.6	1.1	0.83	0.9	0.14	0.10	16.89	0.9	1.00
Iron	NCNS			30	17	0.05	15.2	6.50	4.4	5.93	4.34	91.29	11.7	14.78
Lead, µg/l	Both	100 (T)		30	30	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NCNS			30	0	281	585	370.23	352	71.34	26.00	19.27	373.75	513.5
Manganese	NCNS			30	16	0.016	1.6	0.67	0.375	0.65	0.28	96.80	1.4025	1.58
Mercury, µg/l	HT	10 (T)		30	30	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	30	1	0.13	9.2	3.24	3.03	2.54	1.97	78.32	4.43	7.82
Nitrite as N	NCNS		100	30	27	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.02	0.02
NO3 + NO2	NN	0.132		30	1	0.14	9.2	3.24	3.03	2.54	1.97	78.22	4.45	7.82
pH	Both	6.5 – 9.0		30	0	7.8	8.2	8.07	8.1	0.10	0.10	1.30	8.175	8.20
Selenium, µg/l	Both	50 (T)		30	12	1.2	6	2.84	2.95	1.24	1.00	43.61	3.675	4.30
Sodium	NCNS		1,000	30	0	147	612	321.30	272.5	146.19	97.00	45.50	435.5	576.2
Solids, Dissolved	NCNS		2,000	30	0	2,880	5,680	4,249	4,180	798	730.0	19	4,943	5,401
Solids, Suspended	NCNS			30	15	6	53	20.80	21	13.01	10.00	62.56	27.5	39.00
Sulfate			1,000	30	0	1,800.0	3,700.0	2,516.7	2,495.0	439.4	275.0	17.5	2,690.0	3,229
Vanadium, µg/l	HT; NN	100 (T; D)		30	25	6	40	25.20	20	14.67	14.00	58.21	40	40.00
Zinc	NCNS			30	28	0.02	0.06	0.04	0.04	0.03	0.02	70.71	0.05	0.06

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.4 Coal Mine Wash Alluvial Wells (17, 19, 80R, 83, 193, 197, 200) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		69	56	0.04	0.3	0.07	0.05	0.07	0.01	93.91	0.06	0.17
Arsenic, µg/l	Both	200 (T)		69	65	0.3	5	1.48	0.3	2.35	0.00	159.32	1.475	4.30
Bicarbonate	NCNS			69	0	320	900	593.36	610	187.79	151.0	31.65	750	867.2
Boron, µg/l	NN	5,000		69	0	90	480	252.03	270	105.92	60.00	42.03	320	426.0
Cadmium, µg/l	Both	50 (T)		69	54	0.3	1.6	0.65	0.6	0.34	0.20	52.23	0.75	1.18
Calcium	NCNS			69	0	268	668	460.09	484	107.69	57.00	23.41	528	619.2
Chloride	NCNS			69	0	9.7	230	131.91	150	82.07	60.00	62.21	210	222.6
Chromium, µg/l	Both	1000 (T)		69	69	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		69	0	1,940	7,020	4,926	5,600	1,851	1,200	38	6,570	6,924
Copper, µg/l	HT; NN	500 (T; D)		69	68	60	60	60.00	60	N/A	N/A	N/A	60	60.00
Fluoride	NCNS		2	69	0	0.3	0.7	0.52	0.5	0.08	0.10	15.61	0.6	0.60
Iron	NCNS			69	69	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l	Both	100 (T)		69	68	0.6	0.6	0.60	0.6	N/A	N/A	N/A	0.6	0.60
Magnesium	NCNS			69	0	99.8	665	376.55	448	180.20	121.0	47.85	513	622.0
Manganese	NCNS			69	28	0.006	1.34	0.35	0.15	0.46	0.09	131.77	0.2	1.23
Mercury, µg/l	HT	10 (T)		69	69	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	69	7	0.04	25	6.51	2.245	7.92	1.94	121.65	13.3	21.69
Nitrite as N	NCNS		100	69	68	0.02	0.02	0.02	0.02	N/A	N/A	N/A	0.02	0.02
NO3 + NO2	NN	0.132		69	7	0.04	24.9	6.52	2.245	7.92	1.94	121.53	13.3	21.69
pH	Both	6.5 – 9.0		69	0	7.8	8.3	8.07	8.1	0.10	0.10	1.25	8.1	8.20
Selenium, µg/l	Both	50 (T)		69	58	1.2	3.5	2.07	2	0.69	0.40	33.08	2.25	3.20
Sodium	NCNS		1,000	69	0	59.4	845	484.18	591	283.25	209.0	58.50	749	804.6
Solids, Dissolved	NCNS		2,000	69	0	1,660	7,430	5,014	5,680	2,103	1,490	42	7,000	7,326
Solids, Suspended	NCNS			69	22	6	271	33.13	14	51.23	7.00	154.65	29	147.4
Sulfate			1,000	69	0	920	4,400	2,898	3,400	1,232	800.0	42	4,000	4,212
Vanadium, µg/l	HT; NN	100 (T; D)		69	59	16	60	42.20	50	19.45	10.00	46.08	60	60.00
Zinc	NCNS			69	63	0.02	0.1	0.07	0.07	0.03	0.03	53.07	0.095	0.10

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.5 Moenkopi Wash Mainstem Alluvial Wells (87, 89R, 93, 95,) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		24	21	0.05	0.1	0.07	0.07	0.03	0.02	34.32	0.085	0.10
Arsenic, µg/l	Both	200 (T)		24	20	0.4	5	1.78	0.85	2.16	0.25	121.74	1.925	4.39
Bicarbonate	NCNS			24	0	219	1550	576.71	443.5	308.43	115.0	53.48	670	1,094
Boron, µg/l	NN	5,000		24	0	70	800	231.25	140	204.05	50.00	88.24	225	685.0
Cadmium, µg/l	Both	50 (T)		24	19	0.3	1.4	0.70	0.6	0.42	0.10	59.76	0.7	1.26
Calcium	NCNS			24	0	56.8	502	341.53	371.5	125.04	64.00	36.61	412.25	490.8
Chloride	NCNS			24	0	12	1980	298.17	96	502.44	31.00	168.51	112.5	1,256
Chromium, µg/l	Both	1000 (T)		24	24	ND	ND	ND	ND	N/A		N/A	ND	
Conductivity	<1.5 x background (HT)	NCNS		24	0	612	21,300	6,259	3,925	5,142	1,835	82	7,738	15,885
Copper, µg/l	HT; NN	500 (T; D)		24	24	ND	ND	ND	ND	N/A		N/A	ND	
Fluoride	NCNS		2	24	0	0.4	1.7	0.94	0.75	0.42	0.25	44.84	1.15	1.69
Iron	NCNS			24	22	0.04	1.7	0.87	0.87	1.17	0.83	134.92	1.285	1.62
Lead, µg/l	Both	100 (T)		24	23	0.3	0.3	0.30	0.3	N/A		N/A	0.3	0.30
Magnesium	NCNS			24	0	19.2	2750.0	666.2	365.5	679.5	269.4	102.0	839.3	1,851
Manganese	NCNS			24	3	0.006	2.56	0.68	0.39	0.74	0.34	108.12	0.875	2.21
Mercury, µg/l	HT	10 (T)		24	24	ND	ND	ND	ND	N/A		N/A	ND	
Nitrate as N	NCNS		400	24	0	0.08	5.37	2.19	2.33	1.34	0.81	60.89	3.04	4.59
Nitrite as N	NCNS		100	24	20	0.02	0.07	0.04	0.025	0.02	0.01	68.01	0.04	0.06
NO3 + NO2	NN	0.132		24	0	0.08	5.38	2.21	2.33	1.34	0.82	60.95	3.04	4.68
pH	Both	6.5 – 9.0		24	0	7.9	8.2	8.08	8.1	0.10	0.10	1.25	8.2	8.20
Selenium, µg/l	Both	50 (T)		24	20	1.1	5.1	3.18	3.25	2.17	1.80	68.40	5.025	5.09
Sodium	NCNS		1,000	24	0	40	3210	733.44	301	813.01	219.8	110.85	885	2,238
Solids, Dissolved	NCNS		2,000	24	0	400	24,700	6,851	4,000	6,267	2,340	91	8,713	17,970
Solids, Suspended	NCNS			24	9	6	39	14.93	12	10.23	6.00	68.50	17.5	32.70
Sulfate			1,000	24	0	110	16,000	4,134	2,410	3,883	1,580	94	5,428	10,625
Vanadium, µg/l	HT; NN	100 (T; D)		24	21	8	60	29.33	20	27.23	12.00	92.82	40	56.00
Zinc	NCNS			24	18	0.07	5.81	2.26	1.955	2.13	1.54	94.25	3.09	5.21

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.6 Reed Valley Wash Alluvial Wells (98R, 99R, 165, 199) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		18	13	0.4	2.8	1.22	0.8	0.98	0.40	79.98	1.5	2.54
Arsenic, µg/l	Both	200 (T)		18	17	2	2	2.00	2	N/A	N/A	N/A	2	2.00
Bicarbonate	NCNS			18	0	219	719	411.22	364.5	166.69	103.0	40.54	565.75	686.7
Boron, µg/l	NN	5,000		18	0	100	760	397.78	345	229.46	225.0	57.69	607.5	692.0
Cadmium, µg/l	Both	50 (T)		18	14	0.7	7.2	2.60	1.25	3.08	0.40	118.63	2.925	6.35
Calcium	NCNS			18	0	122	521	390.94	469.5	153.32	16.50	39.22	483.75	510.8
Chloride	NCNS			18	0	14.7	476	219.71	236.5	156.86	114.0	71.40	312.5	470.9
Chromium, µg/l	Both	1000 (T)		18	18	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		18	0	1,580.0	7,580.0	5,294.4	6,300.0	2,252.8	700.0	42.5	6,462.5	7,393
Copper, µg/l	HT; NN	500 (T; D)		18	17	60	60	60.00	60	N/A	N/A	N/A	60	60.00
Fluoride	NCNS		2	18	0	0.2	4.6	1.99	2.455	1.32	1.05	66.14	3.05	3.50
Iron	NCNS			18	10	0.05	2	0.67	0.39	0.70	0.16	104.09	0.7725	1.84
Lead, µg/l	Both	100 (T)		18	18	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NCNS			18	0	48.9	985	509.59	587	308.05	104.5	60.45	657.5	921.3
Manganese	NCNS			18	0	0.06	5.96	1.65	0.4	2.28	0.19	137.49	3.385	5.65
Mercury, µg/l	HT	10 (T)		18	18	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	18	8	0.04	15.6	2.47	0.725	4.77	0.66	193.55	1.755	10.37
Nitrite as N	NCNS		100	18	18	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2	NN	0.132		18	8	0.04	15.6	2.47	0.725	4.77	0.66	193.47	1.7625	10.37
pH	Both	6.5 – 9.0		18	0	7.4	8.2	7.87	8	0.29	0.15	3.64	8.075	8.20
Selenium, µg/l	Both	50 (T)		18	18	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NCNS		1,000	18	0	191.0	764.0	490.4	548.5	198.9	100.0	40.6	576.0	762.3
Solids, Dissolved	NCNS		2,000	18	0	1,260.0	9,150.0	5,520.6	6,495.0	2,703.9	995.0	49.0	6,922.5	8,666
Solids, Suspended	NCNS			18	9	6	38	16.22	8	13.27	2.00	81.82	30	36.00
Sulfate			1,000	18	0	720.0	6,100.0	3,360.7	3,815.0	1,766.1	645.0	52.6	4,200.0	5,684
Vanadium, µg/l	HT; NN	100 (T; D)		18	16	20	40	30.00	30	14.14	10.00	47.14	35	39.00
Zinc	NCNS			18	12	0.02	0.16	0.08	0.07	0.05	0.02	59.16	0.095	0.15

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.7 Red Peak Valley-Yucca Flat-Sagebrush washes Alluvial Wells (29, 104R, 105R, 106R, 172) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Arsenic, µg/l	Both	200 (T)		14	12	0.6	2.0	1.30	1.3	0.99	0.70	76.15	1.65	1.93
Bicarbonate	NCNS			14	0	193	665	424.64	353	164.76	94.50	38.80	604	648.1
Boron, µg/l	NN	5,000		14	0	30	590	235.71	95	227.92	40.00	96.70	500	557.5
Cadmium, µg/l	Both	50 (T)		14	11	0.8	1.5	1.27	1.5	0.40	0.00	31.91	1.5	1.50
Calcium	NCNS			14	0	53.1	487	305.18	356	151.63	90.50	49.69	431.75	461.0
Chloride	NCNS			14	0	5.0	580.0	185.8	70.8	212.4	56.25	114.33	348.5	547.5
Chromium, µg/l	Both	1000 (T)		14	11	20.0	20.0	20.0	20.0	0.0	0.00	0.00	20	20.00
Conductivity	<1.5 x background (HT)	NCNS		14	0	798	6,680	4,068	4,135	2,093	1,995	51	6,120	6,524
Copper, µg/l	HT; NN	500 (T; D)		14	10	20	30	22.50	20	5.00	0.00	22.22	22.5	28.50
Fluoride	NCNS		2	14	0	0.42	1	0.65	0.6	0.15	0.10	23.67	0.775	0.87
Iron	NCNS			14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l	Both	100 (T)		14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NCNS			14	0	24.5	563	259.10	176.5	212.72	123.7	82.10	500	560.4
Manganese	NCNS			14	5	0.007	0.88	0.29	0.011	0.36	0.004	125.14	0.546	0.84
Mercury, µg/l	HT	10 (T)		14	14	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	14	0	0.03	35.3	13.61	11.8	11.96	9.56	87.93	22.375	31.86
Nitrite as N	NCNS		100	14	10	0.03	0.05	0.04	0.035	0.01	0.01	25.53	0.0425	0.05
NO3 + NO2	NN	0.132		14	0	0.03	35.3	13.59	11.85	11.93	9.61	87.76	22.375	31.86
pH	Both	6.5 – 9.0		14	0	8.0	8.4	8.14	8.15	0.12	0.05	1.41	8.2	8.27
Selenium, µg/l	Both	50 (T)		14	5	5.0	33.7	17.23	13	11.43	8.00	66.32	26.3	33.02
Sodium	NCNS		1,000	14	0	90.3	774.0	464.9	459.0	231.2	208.5	49.7	679.8	750.6
Solids, Dissolved	NCNS		2,000	14	0	510	6,550	3,834	3,940	2,231	2,260	58	6,105	6,479
Solids, Suspended	NCNS			14	3	6	18	9.18	8	3.84	2.00	41.85	11	15.50
Sulfate			1,000	14	0	210	3,600	2,101	2,240	1,232	1,130	59	3,223	3,600
Vanadium, µg/l	HT; NN	100 (T; D)		14	10	6	14	10.25	10.5	3.86	3.00	37.68	13.25	13.85
Zinc	NCNS			14	10	0.02	0.08	0.05	0.045	0.03	0.03	67.40	0.0725	0.08

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.8 Dinnebito Wash Alluvial Wells (108R, 168, 169, 170, 201) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		34	30	0.04	0.12	0.07	0.055	0.04	0.01	53.24	0.075	0.11
Arsenic, µg/l	Both	200 (T)		34	29	0.6	5.0	2.0	1.7	1.8	1.10	91.1	2.0	4.40
Bicarbonate	NCNS			34	0	292.0	1,580.0	638.1	688.0	306.3	178.0	48.0	810.3	1,063
Boron, µg/l	NN	5,000		34	0	70	350	181.18	155	90.45	50.00	49.92	257.5	340.0
Cadmium, µg/l	Both	50 (T)		34	31	0.3	0.6	0.50	0.6	0.17	0.00	34.64	0.6	0.60
Calcium	NCNS			34	0	227	647	442.59	483	129.94	67.50	29.36	545.5	591.1
Chloride	NCNS			34	0	15	52	33.25	34.5	12.37	8.50	37.21	42.75	49.35
Chromium, µg/l	Both	1000 (T)		34	34	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		34	0	1,660.0	6,310.0	3,921.8	3,880.0	1,597.9	1,760	40.7	5,375.0	6,141
Copper, µg/l	HT; NN	500 (T; D)		34	31	40	70	60.00	70	17.32	0.00	28.87	70	70.00
Fluoride	NCNS		2	34	2	0.3	0.6	0.44	0.4	0.07	0.03	16.76	0.5	0.60
Iron	NCNS			34	22	0.03	32.9	11.45	6.22	12.82	5.93	111.99	19.925	32.08
Lead, µg/l	Both	100 (T)		34	34	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NCNS			34	0	73.7	577	270.76	251	160.04	169.6	59.11	440.75	512.15
Manganese	NCNS			34	2	0.11	3.52	1.70	1.59	1.25	1.22	73.37	3.0175	3.29
Mercury, µg/l	HT	10 (T)		34	34	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	34	4	0.03	30.1	2.88	0.74	5.71	0.56	198.05	3.7125	8.04
Nitrite as N	NCNS		100	34	23	0.02	0.33	0.09	0.07	0.09	0.01	100.44	0.08	0.22
NO3 + NO2	NN	0.132		34	4	0.03	30.1	2.91	0.75	5.72	0.56	196.45	3.775	8.24
pH	Both	6.5 – 9.0		34	0	7.8	8.1	8.0	8.0	0.1	0.10	1.0	8.0	8.10
Selenium, µg/l	Both	50 (T)		34	27	1.5	16.8	5.6	3.0	5.5	0.40	97.6	6.1	14.40
Sodium	NCNS		1,000	34	0	73.3	686	336.22	304.5	205.79	221.6	61.21	527.25	646.2
Solids, Dissolved	NCNS		2,000	34	0	1,370	6,770	3,914	3,705	1,883	2,105	48	5,600	6,575
Solids, Suspended	NCNS			34	9	6	271	39.32	20	56.16	11.00	142.83	38	105.2
Sulfate			1,000	34	0	690.0	4,100.0	2,239.8	2,075.0	1,168.0	1,245	52.1	3,272.5	3,868
Vanadium, µg/l	HT; NN	100 (T; D)		34	31	7	20	15.67	20	7.51	0.00	47.91	20	20.00
Zinc	NCNS			34	32	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.02	0.02

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.9 Dinnebito Wash, Cumulative Period (1992-2014), Upstream Alluvial Well (108R) Water Quality Summary [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		31	28	0.04	0.20	0.11	0.08	0.08	0.04	78.06	0.14	0.19
Arsenic, µg/l	Both	200 (T)		31	11	1.00	11.00	4.20	2.00	4.09	1.00	97.3	5.00	9.8
Bicarbonate	NCNS			31	0	292.00	429.0	321.5	317.0	29.44	13.50	9.16	326.50	379.9
Boron, µg/l	NN	5,000		31	1	70.00	150.0	103.00	100.00	20.03	10.00	19.44	110.0	145.5
Cadmium, µg/l	Both	50 (T)		31	30	7.00	7.0	7.0	7.0	N/A	N/A	N/A	7.0	7.0
Calcium	NCNS			31	0	479.0	647.0	560.7	567.0	34.42	26.00	6.14	586.5	602.0
Chloride	NCNS			31	0	27.00	77.0	53.6	56.00	12.9	5.00	24.1	61.00	71.0
Chromium, µg/l	Both	1000 (T)		31	29	10.00	90.00	50.00	50.00	56.57	40.00	113.14	70.00	86.0
Conductivity	<1.5 x background (HT)	NCNS		31	0	2,720	4,900	4,088	4,200	449.8	110.0	11.00	4,270	4,800
Copper, µg/l	HT; NN	500 (T; D)		31	28	10.00	60.0	40.0	50.0	26.5	10.0	66.14	55.00	59.00
Fluoride	NCNS		2	31	0	0.40	0.70	0.55	0.60	0.06	0.09	11.69	0.60	0.63
Iron	NCNS			31	24	0.04	0.50	0.16	0.10	0.16	0.06	101.3	0.20	0.41
Lead, µg/l	Both	100 (T)		31	31	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NCNS			31	0	201.00	299.0	243.5	241.0	18.55	10.00	7.62	253.5	267.5
Manganese	NCNS			31	1	0.09	3.52	0.74	0.38	0.86	0.27	116.3	1.04	2.3
Mercury, µg/l	HT	10 (T)		31	31	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	31	11	0.03	1.14	0.23	0.12	0.27	0.08	118.3	0.32	0.66
Nitrite as N	NCNS		100	31	29	0.01	0.05	0.03	0.03	0.03	0.02	94.28	0.04	0.05
NO3 + NO2	NN	0.132		31	11	0.03	1.14	0.23	0.12	0.27	0.08	118.1	0.32	0.66
pH	Both	6.5 – 9.0		31	0	6.10	8.50	7.51	7.40	0.47	0.30	6.22	7.90	8.15
Selenium, µg/l	Both	50 (T)		31	30	1.00	1.00	1.00	1.00	N/A	N/A	N/A	1.00	1.00
Sodium	NCNS		1,000	31	0	274.00	401.0	328.1	325.0	33.5	27.00	10.20	351.0	389.5
Solids, Dissolved	NCNS		2,000	31	0	4,058.0	4,990	4,384	4,350	188	120.0	4.30	4,485	4,630
Sulfate			1,000	31	0	2,390.00	3,160	2,768	2,800	168.7	90.0	6.10	2,875	2,978
Vanadium, µg/l	HT; NN	100 (T; D)		31	29	20.00	40.0	30.0	30.0	14.1	10.0	47.14	35.00	39.00
Zinc	NCNS			31	24	0.01	0.12	0.05	0.03	0.05	0.02	92.18	0.09	0.11

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.10 Dinnebito Wash, Cumulative Period (1992-2014), Downstream Alluvial Well (170) Water Quality Summary [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		64	59	0.05	0.20	0.12	0.12	0.06	0.06	54.04	0.15	0.19
Arsenic, µg/l	Both	200 (T)		20	18	2.00	2.00	2.00	2.00	0.00	0.00	0.00	2.00	2.00
Bicarbonate	NCNS			64	0	550.0	903.0	774.1	796.5	81.44	44.00	10.52	832.3	874.1
Boron, µg/l	NN	5,000		64	0	210.0	380.0	296.9	290.0	39.44	30.00	13.28	330.0	368.5
Cadmium, µg/l	Both	50 (T)		64	61	0.60	20.00	7.07	0.60	11.20	0.00	158.50	10.30	18.1
Calcium	NCNS			64	0	422.0	596.0	509.6	505.0	38.73	28.50	7.60	534.8	574.3
Chloride	NCNS			64	0	32.00	70.00	46.28	46.00	7.61	4.00	16.44	49.00	63.4
Chromium, µg/l	Both	1000 (T)		64	63	40.00	40.00	40.00	40.00	N/A	N/A	N/A	40.00	40.0
Conductivity	<1.5 x background (HT)	NCNS		64	0	4,980	8,580	6,199	6,065	713.7	240.0	11.51	6,350	7,557
Copper, µg/l	HT; NN	500 (T; D)		64	55	10.00	80.00	47.78	50.00	26.35	20.00	55.16	70.00	76.0
Fluoride	NCNS		2	64	1	0.30	0.70	0.45	0.40	0.08	0.10	17.76	0.50	0.60
Iron	NCNS			64	57	0.02	0.14	0.08	0.08	0.05	0.05	58.22	0.12	0.14
Lead, µg/l	Both	100 (T)		64	60	40.00	200.0	87.50	55.00	75.44	10.00	86.22	95.00	179.0
Magnesium	NCNS			64	0	401.0	629.0	489.9	483.5	46.38	24.55	9.47	504.3	591.8
Manganese	NCNS			64	0	0.16	4.84	2.31	1.82	1.34	1.00	58.02	3.74	4.6
Mercury, µg/l	HT	10 (T)		64	62	0.20	0.30	0.25	0.25	0.07	0.05	28.28	0.28	0.30
Nitrate as N	NCNS		400	64	0	0.03	31.50	9.60	6.84	8.20	4.91	85.38	13.05	28.5
Nitrite as N	NCNS		100	64	17	0.01	0.33	0.05	0.03	0.05	0.02	103.3	0.07	0.11
NO3 + NO2	NN	0.132		63	0	0.03	31.50	9.71	6.92	8.22	5.00	84.65	13.10	28.7
pH	Both	6.5 – 9.0		64	0	6.90	8.30	7.56	7.50	0.35	0.30	4.65	7.90	8.2
Selenium, µg/l	Both	50 (T)		64	32	1.00	16.80	4.75	3.50	3.45	1.50	72.68	6.00	10.9
Sodium	NCNS		1,000	64	0	505.0	1,150	675.2	630.5	149.4	74.50	22.13	722.8	981.3
Solids, Dissolved	NCNS		2,000	64	0	5,240	9,540	6,600	6,409	757.9	360.0	11.48	6,810	8,016
Sulfate			1,000	64	0	2,660	5,800	3,996	3,900	526.8	240.0	13.18	4,195	5,202
Vanadium, µg/l	HT; NN	100 (T; D)		64	62	11.00	50.00	30.50	30.50	27.58	19.50	90.42	40.25	48.1
Zinc	NCNS			64	57	0.02	0.10	0.06	0.06	0.03	0.01	50.62	0.07	0.09

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.11 Moenkopi Wash, Cumulative Period (1992-2014), Upstream Alluvial Wells (69, 77, 87) Water Quality Summary [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		86	82	0.05	0.08	0.07	0.07	0.01	0.01	18.64	0.07	0.08
Arsenic, µg/l	Both	200 (T)		86	83	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	1.00
Bicarbonate	NCNS			86	0	205.00	827.00	368.97	361.50	137.82	51.50	37.35	398.00	676.00
Boron, µg/l	NN	5,000		86	2	50.00	330.0	162.9	125.0	95.79	65.00	58.82	260.0	310.0
Cadmium, µg/l	Both	50 (T)		86	80	0.80	6.00	2.67	2.20	2.08	1.40	77.89	3.75	5.50
Calcium	NCNS			86	0	114.0	604.0	250.6	260.0	116.6	87.00	46.56	315.5	446.8
Chloride	NCNS			86	0	4.00	230.0	42.51	39.00	47.20	19.00	111.0	46.00	167.0
Chromium, µg/l	Both	1000 (T)		86	84	10.00	10.00	10.00	10.00	0.00	0.00	0.00	10.00	10.00
Conductivity	<1.5 x background (HT)	NCNS		86	0	663.0	11,900	3,218	3,120	2,536	1,235	78.82	3,777	8,915
Copper, µg/l	HT; NN	500 (T; D)		86	84	10.00	140.0	75.00	75.00	91.92	65.00	122.6	107.5	133.5
Fluoride	NCNS		2	86	0	0.40	1.80	0.94	1.00	0.33	0.13	35.16	1.10	1.60
Iron	NCNS			86	77	0.01	13.40	1.53	0.04	4.45	0.02	291.9	0.06	8.08
Lead, µg/l	Both	100 (T)		86	84	80.00	200.00	140.00	140.00	84.85	60.00	60.61	170.00	194.00
Magnesium	NCNS			86	0	21.20	1,470	308.4	299.5	314.0	141.5	101.8	349.3	1,016
Manganese	NCNS			86	32	0.01	0.49	0.13	0.07	0.13	0.06	100.1	0.20	0.38
Mercury, µg/l	HT	10 (T)		86	85	0.30	0.30	0.30	0.30	N/A	N/A	N/A	0.30	0.30
Nitrate as N	NCNS		400	86	1	0.26	9.71	3.58	2.99	2.36	1.37	65.92	5.00	9.12
Nitrite as N	NCNS		100	86	71	0.01	0.12	0.03	0.02	0.03	0.01	99.28	0.04	0.09
NO3 + NO2	NN	0.132		86	1	0.26	9.71	3.59	2.99	2.36	1.37	65.73	5.00	9.12
pH	Both	6.5 – 9.0		86	0	7.00	8.30	7.69	7.65	0.38	0.35	4.96	8.08	8.20
Selenium, µg/l	Both	50 (T)		86	32	1.00	6.00	2.88	2.00	1.65	1.00	57.30	4.00	6.00
Sodium	NCNS		1,000	86	0	7.20	1,570	252.53	169.50	340.47	89.70	134.8	222.5	1,074.00
Solids, Dissolved	NCNS		2,000	86	0	460.0	15,100	3,364	3,125	3,248	1,382	96.57	3,735	10,950
Sulfate			1,000	86	0	180.0	9,410	1,995	1,885	1,940	756.5	97.20	2,265	6,125
Vanadium, µg/l	HT; NN	100 (T; D)		86	81	8.00	60.00	23.20	20.00	21.43	12.00	92.37	20.00	52.00
Zinc	NCNS			86	75	0.01	0.10	0.03	0.02	0.03	0.01	89.20	0.04	0.07

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-4.12 Moenkopi Wash, Cumulative Period (1992-2014), Downstream Alluvial Wells (19, 95, 172) Water Quality Summary [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		114	104	0.03	0.32	0.11	0.05	0.12	0.01	108.7	0.12	0.31
Arsenic, µg/l	Both	200 (T)		114	95	0.40	7.00	1.61	1.00	1.52	0.30	94.27	2.00	3.48
Bicarbonate	NCNS			115	0	219.00	646.00	427.47	385.00	106.54	36.00	24.92	540.00	625.30
Boron, µg/l	NN	5,000		115	1	30.00	320.0	157.9	120.0	77.36	30.00	49.00	240.0	300.0
Cadmium, µg/l	Both	50 (T)		112	106	0.60	7.00	2.30	1.25	2.46	0.60	107.1	2.63	6.00
Calcium	NCNS			115	0	56.80	590.0	405.9	455.0	121.9	55.50	30.04	495.5	538.4
Chloride	NCNS			115	0	10.00	140.0	58.78	58.50	26.92	17.50	45.80	72.00	117.70
Chromium, µg/l	Both	1000 (T)		112	110	30.00	80.00	55.00	55.00	35.36	25.00	64.28	67.50	77.50
Conductivity	<1.5 x background (HT)	NCNS		115	0	598.0	6,080	3,986	4,190	1,218	915.0	30.54	4,900	5,581
Copper, µg/l	HT; NN	500 (T; D)		112	111	30.00	30.00	30.00	30.00	N/A	N/A	N/A	30.00	30.00
Fluoride	NCNS		2	115	0	0.10	1.20	0.61	0.60	0.17	0.10	27.57	0.70	0.90
Iron	NCNS			115	98	0.02	0.17	0.07	0.06	0.04	0.03	58.74	0.10	0.14
Lead, µg/l	Both	100 (T)		112	111	100.0	100.0	100.0	100.0	N/A	N/A	N/A	100.0	100.0
Magnesium	NCNS			115	0	17.00	610.0	263.7	262.0	136.6	133.5	51.81	394.3	473.5
Manganese	NCNS			115	43	0.01	1.58	0.23	0.13	0.29	0.09	122.4	0.26	0.85
Mercury, µg/l	HT	10 (T)		114	108	0.10	1.30	0.55	0.39	0.54	0.24	99.84	0.76	1.19
Nitrate as N	NCNS		400	115	1	0.04	50.10	13.59	15.06	10.01	5.69	73.66	19.07	28.74
Nitrite as N	NCNS		100	115	83	0.01	0.24	0.04	0.02	0.05	0.01	144.7	0.03	0.16
NO3 + NO2	NN	0.132		115	1	0.04	50.10	13.60	15.05	10.01	5.65	73.57	19.08	28.64
pH	Both	6.5 – 9.0		115	0	7.20	8.50	7.80	7.80	0.33	0.30	4.21	8.08	8.30
Selenium, µg/l	Both	50 (T)		114	36	1.20	57.00	11.55	10.35	10.55	5.35	91.37	13.00	32.43
Sodium	NCNS		1,000	115	0	40.00	737.0	370.6	331.0	137.2	76.00	37.04	492.5	597.7
Solids, Dissolved	NCNS		2,000	115	0	400.0	7,120	3,988	4,154	1,467	1,206	36.79	5,310	5,999
Sulfate			1,000	115	0	90.00	4,200	2,381	2,586	906.9	704.5	38.10	3,063	3,497
Vanadium, µg/l	HT; NN	100 (T; D)		114	108	10.00	30.00	17.50	15.00	8.70	3.00	49.71	19.50	27.90
Zinc	NCNS			114	98	0.02	5.81	1.03	0.10	1.72	0.08	166.86	1.51	4.26

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Appendix WR-5

Wepo Formation Groundwater Levels and Water Quality PWCC Leasehold

This page intentionally left blank

Appendix WR-5. Additional Information - Wepo Formation

Carr (1991) described several facies (individual rock units that formed under particular processes or conditions) in his research on depositional environments of the Wepo Formation. These are depicted in **Figure WR-5.1** and **Figure WR-5.2.** In summary, these rock units were described as:

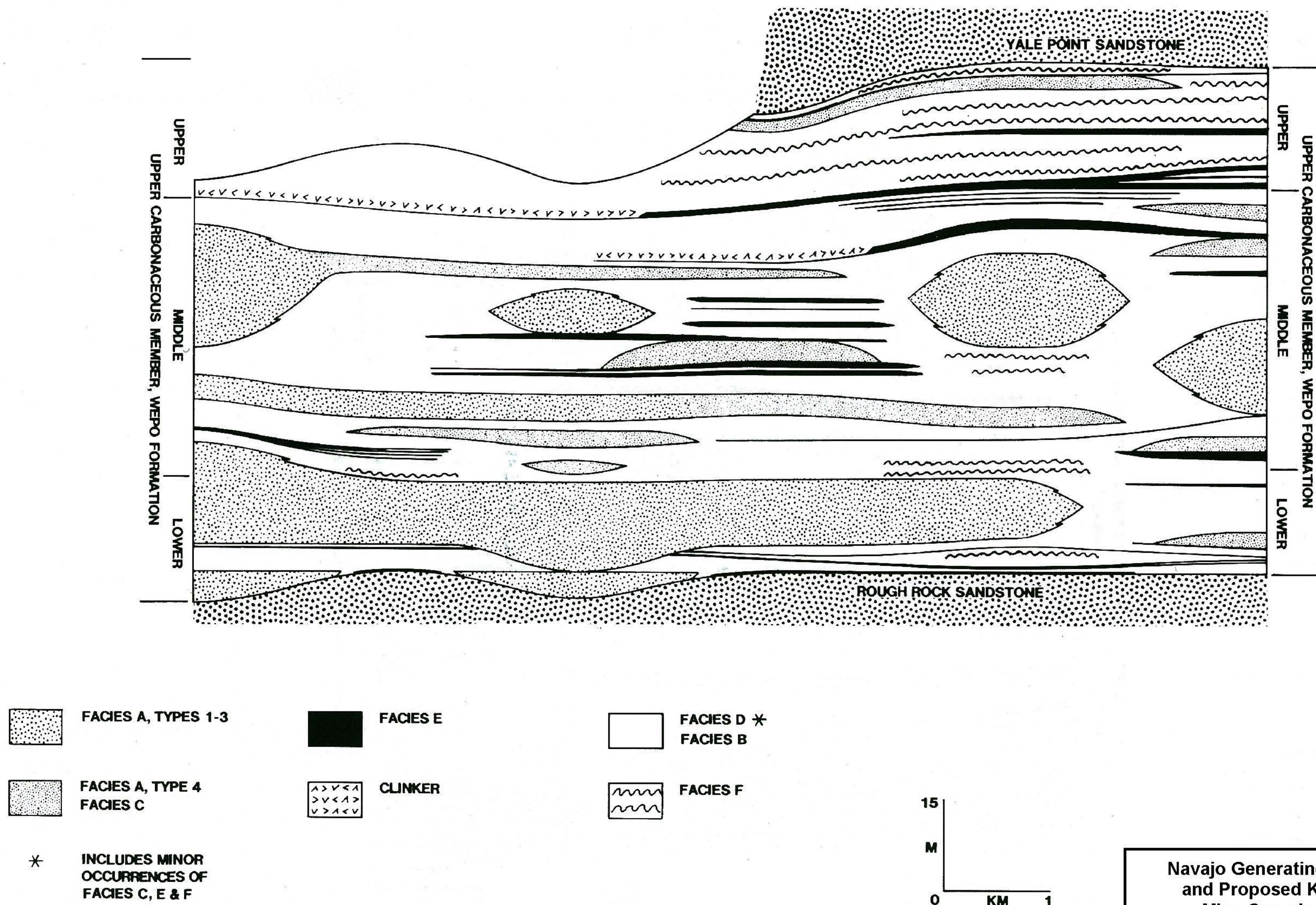
- Facies A: scour-based, cross-bedded sandstones typically occurring as ledges and cliffs. Facies A sandstones are completely encased within, and surrounded by, other facies. Facies A is interpreted as narrow to broad channel deposits similar to the coarse sediments transported in large, modern river systems. Four subcategories described channel sizes and their meandering;
- Facies B: interbedded slope-forming sandstones, siltstones, and mudstones that are approximately 100 to 400 feet in lateral extent. These are interpreted as "levee" deposits that built up from smaller overflows occurring along the margins of river and tributary channels;
- Facies C: thinner ledge-forming sandstones and siltstones that range from about 0.6 to 4 miles in lateral extent. In some locations these deposits can be traced laterally to Facies A deposits. These are interpreted as crevasse-splay deposits, where big floods broke through natural levees along large river channels and splayed out sediment deposits.
- Facies D: mudstones and claystones that range from about 1.5 to 3 miles in lateral extent. These are interpreted as back-swamp or marsh deposits, where fine-grained sediments carried by floods settled out in quieter backwaters on deltas or alluvial plains.
- Facies E: coal, carbonaceous shale, and organic mudrock in isolated beds and interbedded sequences. These range from less than about 0.6 miles to at least 5 miles in extent. Coals terminate laterally by pinching out, by splitting, by grading into carbonaceous shale, or by terminating abruptly against Facies A sandstones. These accumulated in ancient peat-forming environments.
- Facies F: sandstones and mudrocks disturbed by burrowing animals; deposited in shallow bays.

These rocks formed from sediments deposited in a variety of ancient environments, largely on a series of deltaic or alluvial plains containing shifting river systems, marshes, and lakes. Depositional geographies included large stream channels and their tributaries; levee deposits built up along floodplains; sediments splayed out where the levee deposits were broken by floods; marshes and back-swamps; and ponds, lakes or bays forming or shrinking between the rivers.

As a result of these geologic origins, bedrock characteristics vary both vertically and laterally within the Wepo Formation. For example, **Figure WR-5.1** depicts sandstones of Facies A surrounded by finer-textured rocks of Facies D and B. **Figure WR-5.2** depicts a generally similar setting, but where the formation has been progressively eroded by a more recent stream. Because of these factors, hydraulic communication over large distances (more than a few miles) within the Wepo Formation is unlikely. The coals, which are probably the most extensive facies, are broadly lenticular and tend to pinch out into carbonaceous shales. Along with the sandstones, these form locally isolated water-yielding zones. Shales and other fine-grained rocks, and the discontinuous lateral and vertical zonation within the Wepo Formation, inhibit extensive groundwater movement within it.

The underlying Toreva Formation consists of sandy, more consistent and extensive rocks, but it is below the Wepo coal zone and is not disturbed by mining or related pumping. The Toreva Formation does provide a source of groundwater for springs and wells at lower elevations on Black Mesa. The overlying Wepo Formation, however, does not form a regional aquifer system as do the D-Aquifer or N-Aquifer rocks. The Arizona Department of Water Resources (ADWR) describes the combined Yale Point Sandstone, Wepo Formation and Toreva Formation as the "T Aquifer" (ADWR 2008). ADWR describes this unit as mainly unconfined, with perched water zones overlying relatively low-permeability coal, siltstones and mudstones. It has variable water levels, and is likely to have complex flow directions due to the occurrence of perched water-bearing zones (ADWR 2008).

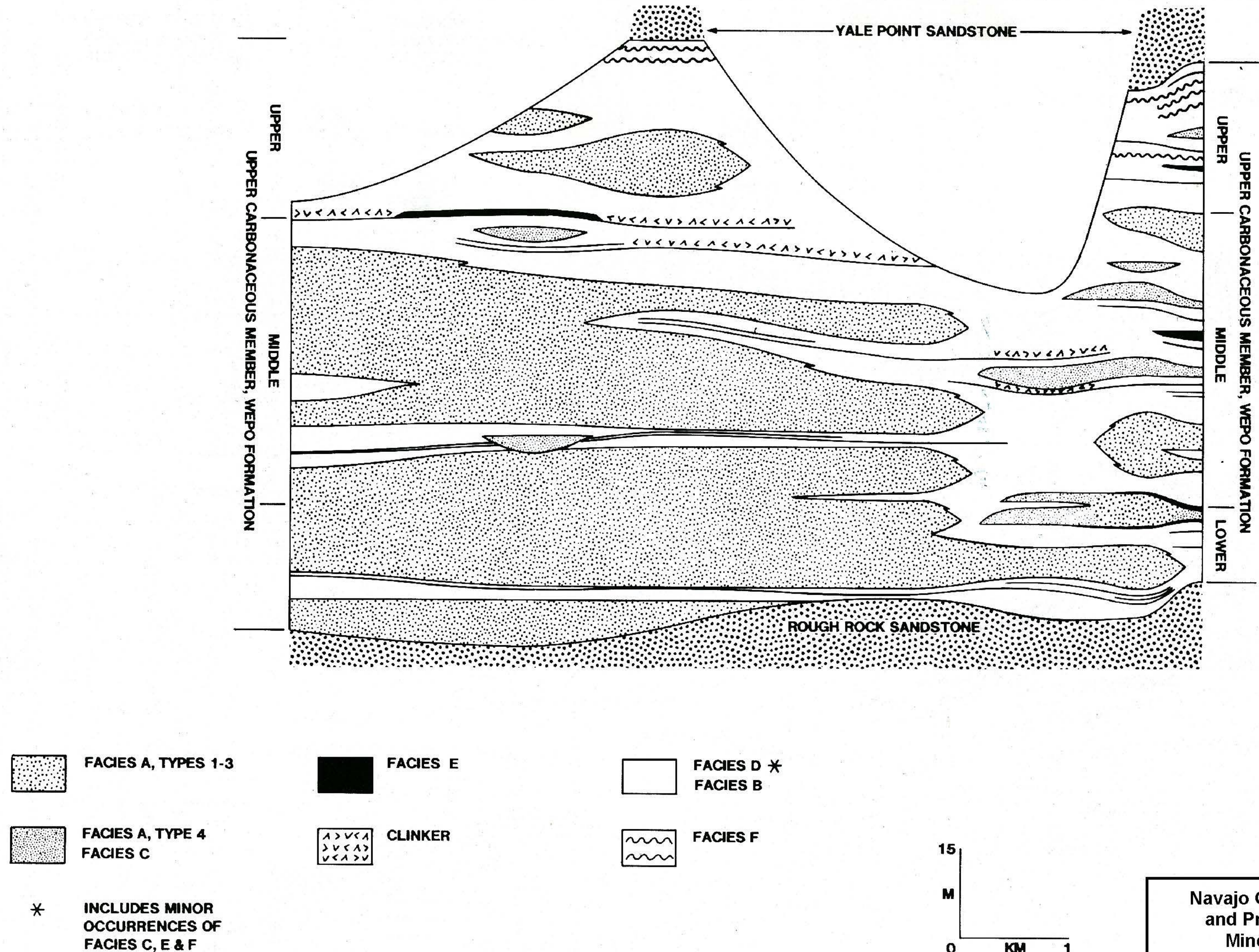
X:\0Projects\SRP_NGS_KMC_60290037\FIGs\DOC\EIS\1_PDEIS\Letter_Sized\Water\FIG_WR_5_1_Wepo1_x_sect1.mxd



Source: Carr 1990

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-5.1
General Wepo Formation Cross-Section 1



Source: Carr 1990

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-5.2
General Wepo Formation Cross-Section 2

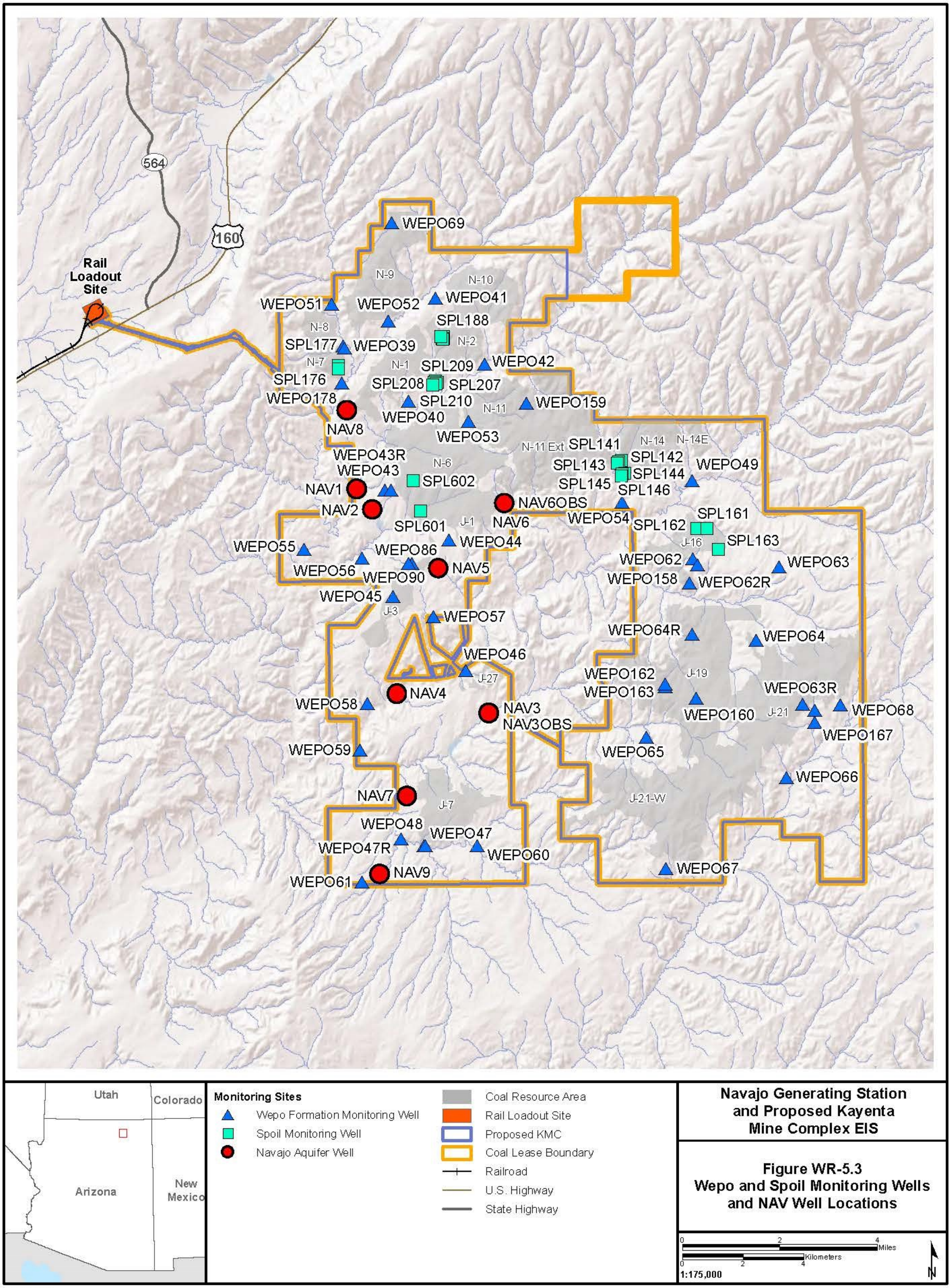
Figure WR-5.3 in indicates the locations of PWCC Wepo Formation monitoring wells. **Tables WR-5.1** and **WR-5.2** indicate changes in water levels within these wells over time, and for recent years. As can be seen in **Table WR-5.1**, many of the water levels have been rising slightly (levels shallower than in previous years). Most of the wells have fairly small fluctuations, on the order of a foot or less since the Year 2005. Wepo Well 52 has larger water level fluctuations beginning in 2007 that may be associated with the initiation of mining in the N9 mine area immediately nearby during that year. Alluvial effects along Yazzie Wash may also affect that site, as could earlier mining activities in areas N6 and N11 to the south. However, Wepo Well 52 was relatively unaffected in 2005 and 2006, and mining was active in both N6 and N11 then. Since 2010, water level changes appear to diminish with time there. Wepo Well 43R is affected by rainwater infiltration at the N6 scoria pit about 0.2 miles distant (PWCC 2014). Wepo Well 65 also has larger water level fluctuations prior to the year 2010. However, it is a mile or more from any mining activities, or otherwise separated by Red Peak Valley Wash and permanent impoundment J7-JR. The impoundment was built in 2001. Those changes at Wepo Well 65 are likely dominated by natural conditions and/or impoundment effects.

Table WR-5.2 indicates that the larger water level changes have occurred at Wepo Wells 52, 53, and 62R. At Site 62R, the 2013 measured water level was approximately 207.4 feet below ground surface (bgs) (PWCC 2014), representing a drop of 9.7 feet from the lowest measured water level of the 1988 through 1995 period (197.7 feet bgs). However, the water level in Wepo Well 62R was about 20 feet higher than its lowest measured value (227.7 feet bgs) in the period 1995 through 2012. At Wepo Well 53, the 2013 measured water level (71.65 feet bgs) was still about 17 feet lower than the lowest measured value during the 1988 through 1995 period, but was about two feet shallower than the lowest measured level in the 1995 through 2012 period. That well is located on a tributary to Coal Mine Wash, between the N6 and N11 mining areas. Wepo Well 52 had a measured water level in 2013 of about 27.6 feet bgs (PWCC 2014). This was 3.8 feet shallower than the lowest measured level in the 1995 through 2012 period, but about 3.3 feet deeper than the lowest measured level in the 1988 through 1995 period. In general, recent data for these wells indicate that the deepest water levels are shallower (rising) compared to those from the 1995 through 2012 period, but are still deeper than the deepest values from the 1988 through 1995 period.

Recent (2010 through 2014) water quality data are available from PWCC for 25 monitoring wells constructed in the Wepo Formation. The locations of these sites are depicted in **Appendix Figure WR-5.3**. For descriptive purposes, the Wepo monitoring wells have been broadly grouped based on their general location or conditions within the coal lease areas. Some wells are located near mine disturbance, whereas others are sufficiently distant from mining activities to essentially reflect background conditions. The groups, or general spatial areas and their associated Wepo monitoring wells are:

- KMC northwest: Wepo wells 41, 42, 51, 52
- KMC northeast: Wepo wells 49, 54, 62R
- KMC southeast: Wepo wells 66, 68
- Former Black Mesa mine area: Wepo wells 40, 43R, 44, 45, 46, 53, 58, 60
- Background: Wepo wells 55, 56, 57, 59, 61, 65, 67, 68

Water quality summaries for these wells, according to their groupings, are presented in **Tables WR-5.3** through **WR-5.7**.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-5.3
Wepo and Spoil Monitoring Wells and NAV Well Locations

7/20/2016

None of the Wepo monitoring wells indicate exceedances of established tribal water quality criteria for livestock watering. In the summarized data, boron concentrations are generally between 100 to 200 mg/L, but range higher and lower. Wells in the northwest part of the KMC (41, 42, 51, and 52) generally reflect a mixed sulfate water type, but with fairly high bicarbonate concentrations as well. Sulfate concentrations range from 60 to 1,600 mg/L, with a median value of 760 mg/L. Bicarbonate concentrations range from 172 to 791 mg/L, with a median value of 306 mg/L. Total dissolved solids (TDS) concentrations range from 270 to 2,990 mg/L, with a median value of 1,370 mg/L. Dissolved trace element concentrations are low; values were not detected in the vast majority of analyses.

Wepo monitoring wells in the northeast part of the KMC (49, 54, and 62R) generally reflect a mixed bicarbonate or sodium bicarbonate water quality. Bicarbonate concentrations range from 264 to 1,930 mg/L, with a median of about 1,018 mg/L. Sulfate concentrations range from 264 to 780 mg/L, with a median of 531 mg/L. Total dissolved solids concentrations range from 1,340 to 2,240 mg/L, with a median value of 1,665 mg/L. Dissolved trace element concentrations are low; values were not detected in the vast majority of analyses.

Water quality in Wepo wells in the southeast part of the KMC (66, 68) is generally a sodium sulfate type somewhat similar to the northwest part of the KMC, but with higher ion concentrations overall. The median TDS concentration is 3,065 mg/L. In the former Black Mesa area (including the Wepo wells listed above), overall water quality is a sodium bicarbonate type somewhat similar to the sampling results for the northeast part of the KMC. Dissolved trace element concentrations in both these areas are low; values were not detected in the vast majority of analyses.

The background monitoring wells for the Wepo Formation (as listed above) are located from the northernmost to the southernmost part of the coal lease areas, but are more concentrated in the southwest. Recent background data reflect mixed, but generally bicarbonate-dominant, water quality types, with a sodium bicarbonate type overall. Overall bicarbonate concentrations range from about 190 to 1,880 mg/L, with a median value of 604 mg/L. Sulfate concentrations range from 20 to 1,090 mg/L, with a median concentration of 168 mg/L. Total dissolved solids concentrations range from 420 to 1,850 mg/L, with a median value of 862 mg/L. Dissolved trace element concentrations are low; values were not detected in the vast majority of analyses.

Table WR-5.1. Wepo Well Water Level Ranges for Select Periods

	Baseline Period		Affected Periods														2006	2007	2008	2009	2010	2011	2012	2013
	1980-1/84		01/84-01/88		1980-01/88		01/88-01/12		2007	2008	2009	2010	2011	2012	2013	2014	Versus	Versus	Versus	Versus	Versus	Versus	Versus	Versus
Well Site	Min	Max	Min	Max	Min	Max	Min	Max	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max	2005	2006	2007	2008	2009	2010	2011	2012
WEPO40	-	-	-	-	71.5	81.0	66.0	80.6	80.2-80.6	79.5-79.9	78.9-79.0	78.0-78.1	77.7	77.0-77.2	76.6	76.2	2.1	0.5	(0.7)	(0.9)	(0.9)	(0.4)	(0.5)	(0.4)
WEPO41	-	-	-	-	86.9	96.2	81.3	94.4	91.1	86.1	90.0	87.9	92.1	93.2	94.7	95.4	0.7	0.6	(5.0)	0.9	(2.1)	4.2	1.1	1.5
WEPO42	-	-	-	-	-2.1	-1.5	-1.8	-1.0	-1.2	-1.4	-1.4	-1.2	-1.2	-1.3 to -1.2	-1.4 to -1.3	-1.5	---	0.1	(0.2)	---	0.2	---	---	(0.1)
WEPO43R	-	-	-	-	-	-	129.1	142.2	139.7	134.3	132.4	130.4	129.1	127.5 *	127.2 *	127.6	(0.2)	(2.2)	(5.4)	(1.9)	(2.0)	(1.3)	(1.6)	(0.3)
WEPO44	-	-	-	-	183.5	187.8	169.2	187.3	171.6	171.3	170.8	169.3	169.2	168.8 *	167.0 *	166.1 *	1.0	(0.9)	(0.3)	(0.5)	(1.5)	(0.1)	(0.4)	(1.8)
WEPO45	-	-	-	-	83.4	88.2	80.0	86.4	83.2	82.9-83.0	82.9	82.2	82.8	82.9	83.2	83.0	---	0.3	(0.2)	(0.1)	(0.7)	0.6	0.1	0.3
WEPO46	-	-	-	-	117.9	157.2	149.8	155.6	155.6	155.3	154.2	154.9	155.2	155.0	155.0	154.4	---	0.4	(0.3)	(1.1)	0.7	0.3	(0.2)	---
WEPO47R								Well is idled									1.5	(1.0)	(1.9)	1.5	0.7	0.2	0.4	
WEPO49	4.3	8.7	4.3	9.6	-	-	0.1	5.7	0.7-0.8	0.1-0.3	0.2-0.4	0.4	0.2	0.2	0.6	0.3	0.2	---	(0.5)	0.1	---	(0.2)	---	0.4
WEPO51	-	-	-	-	43.0	52.0	48.9	56.2	52.1	51.8	52.3	52.4	52.7	52.9	53.0	53.0	0.2	---	(0.3)	0.5	0.1	0.3	0.2	0.1
WEPO52	-	-	-	-	16.3	50.5	17.8	31.0	17.8	23.9-24.5	24.5-25.4	28.5-31.0	30.0-30.5	29.6-30.3	27.6	25.9	0.2	(0.3)	6.7	0.9	5.6	(0.5)	(0.2)	(2.0)
WEPO53	-	-	-	-	36.7	55.4	46.4	73.2	71.5	70.6	70.5	71.4	71.9	72.6	71.6	70.6	0.3	0.1	(0.9)	(0.1)	0.9	0.5	0.7	(1.0)
WEPO54	47.4	55.7	49.9	51.4	-	-	49.5	52.1	51.5	50.4	50.9	51.0	50.7	50.9	51.0	50.5	0.5	0.1	(1.1)	0.5	0.1	(0.3)	0.2	0.1
WEPO55								Well is idled									0.4	0.2	---	---	(0.1)	0.2	0.1	
WEPO56	-	-	-	-	30.9	40.4	32.8	39.7	39.2	39.5	39.5	39.7	39.7	39.6	39.6	39.6	0.9	0.2	0.3	---	0.2	---	(0.1)	---
WEPO57								Well is idled									0.1	0.4	(0.4)	(1.2)	0.4	(0.3)	(0.7)	
WEPO58	-	-	-	-	130.3	140.1	137.5	141.4	141.3	140.9	140.7	140.6	140.6	140.3	140.2	140.1	0.7	(0.1)	(0.4)	(0.2)	(0.1)	---	(0.3)	(0.1)
WEPO59	-	-	-	-	142.7	144.6	142.7	145.8	145.0	143.9	143.8	144.4	144.6	144.7	144.1	144.2	0.3	(0.5)	(1.1)	(0.1)	0.6	0.2	0.1	(0.6)
WEPO60	-	-	-	-	81.2	87.3	88.2	96.3	90.4	91.0-91.4	89.9	89.5	89.5	89.3	88.9	88.6	0.5	(0.1)	1.0	(1.5)	(0.4)	---	(0.2)	(0.4)
WEPO61								Well is idled									0.9	(0.2)	---	(0.2)	(0.3)	0.2	(0.3)	
WEPO62R	-	-	-	-	-	-	205.8	217.8	207.6-208.0	206.5-207.6	205.8-206.3	206.3-206.6	206.2-207.1	207.4-207.5	207.3-207.4	207.1-207.3	(0.5)	0.2	(0.4)	(1.3)	0.3	0.5	0.4	(0.1)
WEPO65	71.9	146.4	106.7	164.5	-	-	113.8	147.1	145.9	141.7	145.6	145.3	145.9	146.2	146.4	147.8	2.5	1.4	(4.2)	3.9	(0.3)	0.6	0.3	0.2
WEPO66	75.4	89.1	86.2	87.3	-	-	77.6	89.4	86.0	77.6	78.2-80.2	79.0	79.0	78.4	78.2	79.4	2.3	(1.3)	(9.4)	2.6	(1.2)	---	(0.6)	(0.2)
WEPO67	129.5	204.5	185.6	191.6	-	-	175.9	187.7	185.7	184.9	184.2	183.2	182.4	180.9	178.8	177.3	0.6	(0.1)	(0.8)	(0.7)	(1.0)	0.2	(1.5)	(2.1)
WEPO68	-	-	-	-	-	-	107.2	110.8	110.2	109.5	109.0	108.3	107.2	107.4	106.8	106.6 *	0.2	(0.5)	(0.7)	(0.5)	(0.7)	(1.1)	0.2	(0.6)
WEPO69	-	-	-	-	-	-	-	-	-	-	-	-	-	112.7-118.9	111.8-111.9	111.8 *	-	-	-	-	-	-	-	(0.9)

Source: PWCC 2014

All values given are in feet below ground surface.

			2006 vs 2005	2007 vs 2006	2008 vs 2007	2009 vs 2008	2010 vs 2009	2011 vs 2010	2012 vs 2011	2013 vs 2012
*	Historic mininum water level for these wells	Idled wells	-	-	-	-	-	-	-	4
**	Historic maximum water level for these wells	New well	-	-	-	-	-	-	1	-
0.9	Water level deeper than in previous year	Deeper	20	12	3	8	11	12	11	6
(0.2)	Water level shallower than in previous year	Shallower	2	11	20	14	13	8	12	14
---	No change in water level over previous year	No change	3	2	2	3	1	5	2	2
			25	25	25	25	25	25	26	26

This page intentionally left blank

Table WR-5.2 Wepo Well Water Level Fluctuations, where there are No Baseline Water Level Data

Well Site	1/80-1/88 Water Level Range (ft.)	1/80-1/88 Water Level Fluctuation (ft)	1/88-1/95 Water Level Range (ft.)	1/88-1/95 Water Level Fluctuation (ft)	1995-2012 Drawdown Compared to 1/88-1/95 Levels [a] Range (ft)	1995-2012 Drawdown Compared to 1/88-1/95 Levels [a] Overage (ft)	2013 Drawdown Compared to 1/88-1/95 Levels (ft)	Maximum Predicted Drawdowns (ft) [b]	Ponds in near Vicinity
WEPO40	71.5-81.0	9.5	66.0-74.4	8.4	67.1-80.6	6.2	2.2	47	N1-M
WEPO41	86.9-93.4	6.5	81.3-94.4	13.1	86.1-93.2	---	Within	26	None
WEPO42	(-2.1) - (-1.5)	0.6	(-1.8) - (-1.3)	0.5	(-1.7) - (-1.0)	0.3	Within	54	N10-A1
WEPO43R	138.6-151.5	12.9	138.9-144.5	5.6	127.5-143.2	---	Within [d]	43	None
WEPO44	183.5-187.8	4.3	177.7-187.3	9.6	168.8-180.9	---	Within [d]	49	J1-A, J1-RB
WEPO45	83.4-88.2	4.8	80.0-86.4	6.4	80.8-83.2	---	Within	37	PII-117
WEPO46	117.9-157.2	39.3	149.8-155.4	5.6	151.2-155.6	0.2	Within	38	J27-A, J27-RC
WEPO47R	Well is idled								
WEPO51	43.0-52.0	9.0	48.9-52.1	3.2	51.2-53.2	1.1	0.9	26	None
WEPO52	16.3-24.3	8.0	18.0-23.8	5.8	17.8-31.0	7.2	3.8	35	N9-C, N9-C1
WEPO53	36.7-55.4	18.7	46.4-54.7	8.3	54.8-73.2	18.5	16.9	65	N12-C2
WEPO55	Well is idled								
WEPO56	30.9-40.4	9.5	32.8-38.4	5.6	35.0-39.7	1.3	1.2	35	J2-A
WEPO57	Well is idled								
WEPO58	130.3-140.1	9.8	137.5-141.2	3.7	140.0-141.4	0.2	Within	24	None
WEPO59	142.7-144.6	1.9	142.7-144.3	1.6	143.1-145.8	1.5	Within	20	None
WEPO60	81.2-87.3	6.1	88.2-95.7	7.5	89.3-93.7	---	Within	19	None
WEPO61	Well is idled								
WEPO62R	114.1-160.3	46.2	133.2-197.7	64.5	167.1-227.7	30.0	9.7	63	None
WEPO68 [	107.0-117.2	10.2	106.2-113.4	7.2	106.7-119.3	5.9	Within	37	J21-A & -A1
WEPO69	---	---	---	---	112.7-118.9	[e]	[d], [e]	n/a	None

Notes:

[a] Pre-2013/post-1/88-1/95 maximum drawdown compared with 1/88-1/95 maximum.

[b] Maximum predicted drawdowns are taken from Table 8, Chapter 18, AZ-0001E PAP, as revised.

[c] Background and historic levels through 1997 for these three wells are taken from 43, 62, and 64R, respectively, corrected for ground surface elevation.

[d] Minimum historic drawdown occurred during 2013 at these wells.

[e] Well installed in 2012, therefore no historic data are available for comparison.

This page intentionally left blank

Table WR-5.3 Wepo Aquifer Wells (41, 42, 51, 52) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		25	22	0.1	0.1	0.1	0.1	0.0	0.0	20.38	0.1	0.1
Arsenic, µg/l	Both	200 (T)		25	21	0.6	0.8	0.8	0.8	0.1	0.0	13.33	0.8	0.8
Bicarbonate	NCNS			25	0	172.0	791.0	351.8	306.0	185.4	74.0	52.70	333.0	702.6
Boron, µg/l	NN	5,000		25	0	70.0	630.0	169.2	110.0	151.0	10.0	89.24	120.0	460.0
Cadmium, µg/l	Both	50 (T)		25	24	0.2	0.2	0.2	0.2	N/A	N/A	N/A	0.2	0.2
Calcium	NCNS			25	0	30.0	249.0	124.4	157.0	88.4	92.0	71.05	211.0	239.4
Chloride	NCNS			25	0	6.0	41.0	13.7	9.0	11.4	2.0	83.56	10.4	37.5
Chromium, µg/l	Both	1000 (T)		25	25	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		25	0	486.0	3,870.0	1,758.2	1,660.0	1,130.3	100.0	64.3	1,730.0	3,808.0
Copper, µg/l	HT; NN	500 (T; D)		25	24	20.0	20.0	20.0	20.0	N/A	N/A	N/A	20.0	20.0
Fluoride	NCNS		2	25	0	0.2	4.2	1.4	1.8	1.2	1.3	83.10	1.9	3.4
Iron	NCNS			25	9	0.03	10.90	2.72	0.90	4.00	0.67	147.29	2.27	10.68
Lead, µg/l	Both	100 (T)		25	25	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NCNS			25	0	10.8	137.0	69.5	92.7	51.8	44.3	74.54	124.0	133.6
Manganese	NCNS			25	3	0.03	0.39	0.14	0.07	0.13	0.03	87.30	0.21	0.39
Mercury, µg/l	HT	10 (T)		25	24	3.9	3.9	3.9	3.9	N/A	N/A	N/A	3.9	3.9
Nitrate as N	NCNS		400	25	11	0.04	0.44	0.18	0.11	0.16	0.06	87.61	0.30	0.43
Nitrite as N	NCNS		100	25	24	0.03	0.03	0.03	0.03	N/A	N/A	N/A	0.03	0.03
NO3 + NO2	NN	0.132		25	10	0.03	0.44	0.17	0.09	0.15	0.04	92.22	0.27	0.43
pH	Both	6.5 – 9.0		25	0	8.00	8.40	8.20	8.20	0.13	0.10	1.53	8.30	8.40
Selenium, µg/l	Both	50 (T)		25	25	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NCNS		1,000	25	0	35.1	898.0	205.0	42.0	320.6	6.9	156.44	72.0	847.0
Solids, Dissolved	NCNS		2,000	25	0	270.0	2,990.0	1,340.4	1,370.0	844.0	80.0	63.0	1,410.0	2,798.0
Solids, Suspended	NCNS			25	18	12.0	51.0	22.3	17.0	13.4	2.0	60.07	22.5	43.5
Sulfate			1,000	25	0	60.0	1,600.0	701.3	760.0	475.0	51.0	67.7	802.0	1,400.0
Vanadium, µg/l	HT; NN	100 (T; D)		25	24	14.0	14.0	14.0	14.0	N/A	N/A	N/A	14.0	14.0
Zinc	NCNS			25	24	0.03	0.03	0.03	0.03	N/A	N/A	N/A	0.03	0.0

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.4 Wepo Aquifer Wells (49, 54, 62R) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		20	16	0.0	0.1	0.0	0.0	0.0	0.0	12.83	0	0
Arsenic, µg/l	Both	200 (T)		20	13	0.5	2.0	1.4	2.0	0.8	0.0	59.08	2	2
Bicarbonate	NCNS			20	0	264.0	1,930.0	1,022.5	1,017.5	675.7	642.5	66.1	1,660.0	1,740.0
Boron, µg/l	NN	5,000		20	0	70.0	310.0	188.0	180.0	102.2	100.0	54.37	283	310
Cadmium, µg/l	Both	50 (T)		20	19	0.2	0.2	0.2	0.2	N/A	N/A	N/A	0	0
Calcium	NCNS			20	0	45.1	249.0	137.7	128.0	91.1	81.5	66.15	226	240
Chloride	NCNS			20	0	9.0	41.0	24.8	25.0	14.6	14.0	58.75	39	40
Chromium, µg/l	Both	1000 (T)		20	20	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		20	0	1,640.0	3,260.0	2,376.5	2,335.0	704.8	655.0	29.7	3,042.5	3,184.0
Copper, µg/l	HT; NN	500 (T; D)		20	19	20.0	20.0	20.0	20.0	N/A	N/A	N/A	20	20
Fluoride	NCNS		2	20	0	0.2	4.6	2.3	2.1	2.1	1.9	92.8	4.3	4.6
Iron	NCNS			20	9	0.03	2.4	1.3	1.1	1.0	1.0	72.9	2.2	2.3
Lead, µg/l	Both	100 (T)		20	20	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium	NCNS			20	0	9.7	130.0	60.1	52.5	51.3	42.7	85.35	106	121
Manganese	NCNS			20	0	0.04	0.39	0.14	0.09	0.13	0.05	93.35	0.17	0.39
Mercury, µg/l	HT	10 (T)		20	20	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	20	10	0.05	0.44	0.19	0.19	0.12	0.08	65.18	0.23	0.38
Nitrite as N	NCNS		100	20	20	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2	NN	0.132		20	10	0.05	0.44	0.19	0.19	0.12	0.08	65.18	0.23	0.38
pH	Both	6.5 – 9.0		20	0	7.90	8.40	8.24	8.25	0.17	0.15	2.06	8.40	8.40
Selenium, µg/l	Both	50 (T)		20	20	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NCNS		1,000	20	0	35.1	805.0	392.1	371.8	362.6	335.4	92.48	744	804
Solids, Dissolved	NCNS		2,000	20	0	1,340.0	2,240.0	1,741.0	1,665.0	368.8	295.0	21.2	2,127.5	2,240.0
Solids, Suspended	NCNS			20	10	6.0	30.0	17.4	17.5	8.6	7.5	49.68	23	30
Sulfate			1,000	20	0	264.0	780.0	521.9	531.0	204.3	196.0	39.15	702	761
Vanadium, µg/l	HT; NN	100 (T; D)		20	18	7.0	10.0	8.5	8.5	2.1	1.5	24.96	9	10
Zinc	NCNS			20	20	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.5 Wepo Aquifer Wells (66, 68) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		10	8	0.04	0.05	0.05	0.05	0.01	0.01	15.71	0.05	0.05
Arsenic, µg/l	Both	200 (T)		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Bicarbonate	NCNS			10	0	591.0	1,260.0	840.9	754.5	265.3	162.0	31.5	1,065.0	1,206.0
Boron, µg/l	NN	5,000		10	0	140.0	340.0	210.0	185.0	71.3	45.0	33.97	258	318
Cadmium, µg/l	Both	50 (T)		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium	NCNS			10	0	2.70	542.00	225.69	173.75	239.29	170.85	106.03	449.75	507.80
Chloride	NCNS			10	0	17.00	74.00	42.19	39.00	25.91	21.65	61.41	66.40	72.20
Chromium, µg/l	Both	1000 (T)		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		10	0	1,580.0	5,760.0	3,667.0	3,570.0	2,060.5	1,950.0	56.2	5,632.5	5,755.5
Copper, µg/l	HT; NN	500 (T; D)		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	NCNS		2	10	1	0.40	6.60	3.50	5.30	2.90	1.30	82.70	6.00	6.44
Iron	NCNS			10	5	0.60	1.89	1.08	0.97	0.54	0.35	50.02	1.30	1.77
Lead, µg/l	Both	100 (T)		10	9	0.20	0.20	0.20	0.20	N/A	N/A	N/A	0.20	0.20
Magnesium	NCNS			10	0	1.90	352.00	141.53	102.35	151.21	100.35	106.84	274.00	329.50
Manganese	NCNS			10	5	0.21	0.43	0.29	0.29	0.08	0.05	28.33	0.30	0.40
Mercury, µg/l	HT	10 (T)		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	10	9	0.57	0.57	0.57	0.57	N/A	N/A	N/A	0.57	0.57
Nitrite as N	NCNS		100	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2	NN	0.132		10	9	0.57	0.57	0.57	0.57	N/A	N/A	N/A	0.57	0.57
pH	Both	6.5 – 9.0		10	0	7.8	8.8	8.3	8.3	0.5	0.4	5.4	8.7	8.8
Selenium, µg/l	Both	50 (T)		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NCNS		1,000	10	0	405.0	957.0	611.7	564.0	215.5	157.5	35.2	768.0	914.3
Solids, Dissolved	NCNS		2,000	10	0	980.0	5,660.0	3,213.0	3,065.0	2,233.6	1,975.0	69.5	5,320.0	5,610.5
Solids, Suspended	NCNS			10	6	7.0	11.0	8.3	7.5	1.9	0.5	22.9	8.8	10.6
Sulfate			1,000	10	0	251.0	3,140.0	1,630.8	1,520.0	1,406.3	1,249.5	86.2	2,997.5	3,104.0
Vanadium, µg/l	HT; NN	100 (T; D)		10	8	7.0	60.0	33.5	33.5	37.5	26.5	111.9	46.8	57.4
Zinc	NCNS			10	9	0.05	0.05	0.05	0.05	N/A	N/A	N/A	0.05	0.05

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.6 Wepo Aquifer Wells, Black Mesa Mine Area (40, 43R, 44, 45, 46, 53, 58, 60) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		38	34	0.04	0.04	0.04	0.04	0.00	0.00	0.00	0.04	0.04
Arsenic, µg/l	Both	200 (T)		38	27	0.30	1.70	0.70	0.60	0.37	0.10	53.45	0.75	1.3
Bicarbonate	NCNS			38	0	300.0	1,510.0	845.6	837.5	309.3	163.0	36.6	984.8	1,451.5
Boron, µg/l	NN	5,000		38	0	90.0	660.0	268.4	210.0	164.2	105.0	61.17	358	580.0
Cadmium, µg/l	Both	50 (T)		38	37	0.20	0.20	0.20	0.20	N/A	N/A	N/A	0.20	0.20
Calcium	NCNS			38	0	1.90	228.00	64.36	31.05	71.32	27.25	110.82	128.25	192.90
Chloride	NCNS			38	0	7.00	66.00	32.66	23.50	19.14	6.50	58.62	55.88	62.09
Chromium, µg/l	Both	1000 (T)		38	38	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		38	0	1,010.0	4,780.0	2,463.7	2,350.0	1,181.9	910.0	48.0	3,295.0	4,686.5
Copper, µg/l	HT; NN	500 (T; D)		38	38	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	NCNS		2	38	3	0.70	10.60	5.15	6.30	3.52	3.50	68.34	8.20	10.23
Iron	NCNS			38	14	0.09	4.10	1.19	1.09	1.07	0.70	90.17	1.70	3.22
Lead, µg/l	Both	100 (T)		38	37	60.00	60.00	60.00	60.00	N/A	N/A	N/A	60.00	60.00
Magnesium	NCNS			38	0	0.60	191.00	38.39	20.10	46.99	19.25	122.40	62.23	127.30
Manganese	NCNS			38	5	0.01	0.46	0.13	0.09	0.14	0.07	108.87	0.15	0.44
Mercury, µg/l	HT	10 (T)		38	38	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	38	29	0.04	0.32	0.14	0.13	0.09	0.08	66.41	0.19	0.28
Nitrite as N	NCNS		100	38	37	0.03	0.03	0.03	0.03	N/A	N/A	N/A	0.03	0.03
NO3 + NO2	NN	0.132		38	29	0.04	0.32	0.15	0.14	0.09	0.07	64.37	0.19	0.28
pH	Both	6.5 – 9.0		38	0	7.70	8.80	8.37	8.45	0.32	0.15	3.82	8.60	8.80
Selenium, µg/l	Both	50 (T)		38	37	3.00	3.00	3.00	3.00	N/A	N/A	N/A	3.00	3.00
Sodium	NCNS		1,000	38	0	116.0	1,170.0	505.4	554.5	305.5	194.5	60.5	614.8	1,124.5
Solids, Dissolved	NCNS		2,000	38	0	650.0	3,570.0	1,731.1	1,505.0	947.4	520.0	54.7	2,637.5	3,415.0
Solids, Suspended	NCNS			38	31	6.0	49.0	17.6	11.0	15.8	3.0	90.1	20.0	43.0
Sulfate			1,000	38	4	20.0	1,850.0	690.1	475.0	642.8	340.0	93.1	1,437.5	1,752.5
Vanadium, µg/l	HT; NN	100 (T; D)		38	37	10.00	10.00	10.00	10.00	N/A	N/A	N/A	10.00	10.00
Zinc	NCNS			38	33	0.03	0.06	0.04	0.05	0.01	0.01	30.49	0.05	0.06

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.7. Wepo Aquifer Wells, Background - likely not affected by mining (55, 56, 57, 59, 61, 65, 67, 69) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		32	21	0.04	0.10	0.06	0.05	0.02	0.01	37.04	0.08	0.095
Arsenic, µg/l	Both	200 (T)		32	17	0.70	8.00	2.81	1.60	2.25	0.80	80.31	4.30	6.46
Bicarbonate	NCNS			32	0	191.00	1,880.00	743.78	604.50	528.53	340.00	71.06	1,122.50	1738
Boron, µg/l	NN	5,000		32	0	80.00	860.00	303.44	220.00	245.15	125.00	80.79	387.50	850
Cadmium, µg/l	Both	50 (T)		32	31	0.40	0.40	0.40	0.40	N/A	N/A	N/A	0.40	0.4
Calcium	NCNS			32	0	2.80	166.00	23.62	8.65	46.11	5.20	195.18	16.25	162.45
Chloride	NCNS			32	0	5.00	43.00	13.53	12.00	9.68	2.00	71.59	13.00	41
Chromium, µg/l	Both	1000 (T)		32	32	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity	<1.5 x background (HT)	NCNS		32	0	743.0	2,520.0	1,536.8	1,410.0	614.8	513.0	40.0	1,985.0	2,490.0
Copper, µg/l	HT; NN	500 (T; D)		32	32	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	NCNS		2	32	5	0.16	9.80	3.74	2.20	3.41	2.00	90.99	6.85	9.57
Iron	NCNS			32	18	0.03	0.55	0.22	0.18	0.20	0.13	90.43	0.34	0.55
Lead, µg/l	Both	100 (T)		32	29	0.20	0.20	0.20	0.20	0.00	0.00	0.00	0.20	0.20
Magnesium	NCNS			32	0	0.40	87.90	11.24	2.00	24.58	1.20	218.69	7.23	84.39
Manganese	NCNS			32	6	0.01	0.24	0.05	0.03	0.07	0.01	124.35	0.04	0.22
Mercury, µg/l	HT	10 (T)		32	32	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	32	23	0.03	1.31	0.66	1.02	0.60	0.29	90.63	1.18	1.29
Nitrite as N	NCNS		100	32	32	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2	NN	0.132		32	23	0.03	1.31	0.66	1.02	0.60	0.29	90.63	1.18	1.29
pH	Both	6.5 – 9.0		32	0	8.10	8.80	8.53	8.60	0.20	0.10	2.40	8.70	8.75
Selenium, µg/l	Both	50 (T)		32	31	1.20	1.20	1.20	1.20	N/A	N/A	N/A	1.20	1.20
Sodium	NCNS		1,000	32	0	154.00	632.00	343.88	327.00	154.70	136.50	44.99	458.25	621.15
Solids, Dissolved	NCNS		2,000	32	0	420.00	1,850.00	1,013.88	862.00	473.11	322.00	46.66	1,310.00	1,814.50
Solids, Suspended	NCNS			32	24	6.00	46.00	17.00	10.00	14.88	3.50	87.53	20.50	41.80
Sulfate			1,000	32	9	20.00	1,090.00	260.04	168.00	327.25	92.00	125.84	240.00	1,056.00
Vanadium, µg/l	HT; NN	100 (T; D)		32	27	6.00	8.00	6.80	7.00	0.84	1.00	12.30	7.00	7.80
Zinc	NCNS			32	29	0.02	0.84	0.32	0.11	0.45	0.09	139.08	0.48	0.767

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.8. Wepo Aquifer Wells, Background - likely not affected by mining (55, 56, 57, 59, 61, 65, 67, 69) Cumulative Water Quality Summary, 1980 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		158	124	0.04	3.10	0.62	0.24	0.79	0.20	128.9	1.00	2.26
Arsenic, µg/l	Both	200 (T)		157	121	0.70	40.00	4.70	1.60	9.01	0.60	191.8	3.25	30.00
Bicarbonate	NCNS			159	0	138.47	2,358.99	722.12	479.46	553.91	237.46	76.7	968.00	1,777.90
Boron, µg/l	NN	5,000		151	24	1.00	1,200	288.1	210.0	258.3	110.00	89.67	320.0	860.0
Cadmium, µg/l	Both	50 (T)		162	136	0.40	10.00	6.13	6.00	2.53	1.50	41.25	7.75	10.00
Calcium	NCNS			159	1	2.00	188.0	28.74	10.00	46.31	6.00	161.1	19.85	159.3
Chloride	NCNS			161	2	3.00	62.70	17.17	13.00	12.64	5.00	73.63	19.40	42.75
Chromium, µg/l	Both	1000 (T)		158	154	10.00	50.00	30.00	30.00	18.26	15.00	60.86	42.50	48.50
Conductivity	<1.5 x background (HT)	NCNS		116	0	500.0	4,590	1,610	1,410	805.0	572.0	49.99	2,205	2,930
Copper, µg/l	HT; NN	500 (T; D)		158	140	1.00	20.00	7.22	6.00	4.36	3.50	60.36	10.00	11.50
Fluoride	NCNS		2	162	5	0.10	15.50	2.47	1.50	2.97	1.28	120.1	3.00	8.80
Iron	NCNS			158	64	0.01	4.20	0.25	0.08	0.53	0.05	208.8	0.23	0.96
Lead, µg/l	Both	100 (T)		158	132	0.20	120.0	54.64	60.00	33.57	20.00	61.45	77.50	110.0
Magnesium	NCNS			159	11	0.40	89.00	14.44	3.35	25.72	2.35	178.1	8.00	84.00
Manganese	NCNS			159	21	0.01	0.75	0.11	0.05	0.13	0.03	121.0	0.15	0.40
Mercury, µg/l	HT	10 (T)		162	160	1.00	2.00	1.50	1.50	0.71	0.50	47.14	1.75	1.95
Nitrate as N	NCNS		400	161	87	0	2.60	0.25	0.10	0.41	0.08	161.3	0.32	1.09
Nitrite as N	NCNS		100	157	101	0	0.65	0.04	0.01	0.10	0.01	230.5	0.04	0.19
NO3 + NO2	NN	0.132		54	38	0.03	1.31	0.52	0.35	0.50	0.31	96.63	1.03	1.28
pH	Both	6.5 – 9.0		122	0	7.10	8.80	8.12	8.20	0.39	0.30	4.82	8.40	8.70
Selenium, µg/l	Both	50 (T)		162	157	1.00	2.00	1.44	1.20	0.52	0.20	35.95	2.00	2.00
Sodium	NCNS		1,000	161	0	117.0	732.0	332.4	278.5	165.1	88.00	49.66	432.5	672.3
Solids, Dissolved	NCNS		2,000	160	0	401.0	3,929	1,089	880.0	564.3	351.0	51.80	1,564	1,837
Sulfate			1,000	156	14	4.00	1,323	266.6	160.0	346.0	137.0	129.8	296.0	1,091
Vanadium, µg/l	HT; NN	100 (T; D)		158	150	6.00	30.00	11.75	7.50	8.70	1.50	74.02	12.50	26.50
Zinc	NCNS			158	115	0.01	2.30	0.12	0.03	0.37	0.02	301.02	0.08	0.43

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.9. Wepo Aquifer Wells, Northwest (41, 42, 51, 52) Cumulative Water Quality Summary, 1980 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		109	91	0.05	4.50	0.47	0.08	1.09	0.03	233.2	0.15	2.04
Arsenic, µg/l	Both	200 (T)		109	94	0.60	30.00	5.40	1.00	10.03	0.40	185.8	3.00	30.00
Bicarbonate	NCNS			110	0	125.66	1,038.60	429.94	361.06	178.37	67.41	41.5	480.07	744.75
Boron, µg/l	NN	5,000		109	14	40.00	2,600	275.8	160.0	306.4	80.00	111.1	414.5	620.0
Cadmium, µg/l	Both	50 (T)		110	92	0.20	20.00	9.07	9.00	4.28	1.00	47.20	10.00	15.75
Calcium	NCNS			110	0	5.00	249.0	99.00	87.00	71.43	62.00	72.15	164.5	220.0
Chloride	NCNS			110	1	2.90	68.00	20.48	16.00	15.08	8.00	73.63	28.10	50.44
Chromium, µg/l	Both	1000 (T)		109	107	10.00	50.00	30.00	30.00	28.28	20.00	94.28	40.00	48.00
Conductivity	<1.5 x background (HT)	NCNS		87	0	486.0	5,500	2,004	1,680	1,243	800.0	62.00	2,820	4,100
Copper, µg/l	HT; NN	500 (T; D)		109	91	2.00	50.00	16.94	10.00	12.88	3.50	76.02	20.00	41.50
Fluoride	NCNS		2	110	0	0.16	4.17	1.72	1.86	0.83	0.60	48.27	2.13	3.16
Iron	NCNS			109	21	0.02	10.90	2.31	0.64	3.32	0.56	143.37	2.53	9.83
Lead, µg/l	Both	100 (T)		109	86	20.00	220.0	86.96	90.00	49.12	30.00	56.49	105.0	168.0
Magnesium	NCNS			110	1	1.50	137.0	61.03	60.00	41.88	38.30	68.62	98.30	124.0
Manganese	NCNS			109	8	0.02	0.39	0.14	0.13	0.09	0.06	61.96	0.18	0.33
Mercury, µg/l	HT	10 (T)		110	108	0.20	3.90	2.05	2.05	2.62	1.85	127.6	2.98	3.72
Nitrate as N	NCNS		400	110	63	0.00	0.49	0.12	0.08	0.13	0.06	106.5	0.17	0.43
Nitrite as N	NCNS		100	109	80	0.00	0.65	0.06	0.01	0.14	0.01	236.7	0.03	0.21
NO3 + NO2	NN	0.132		38	19	0.03	0.49	0.19	0.13	0.16	0.08	85.15	0.33	0.45
pH	Both	6.5 – 9.0		87	0	6.60	8.40	7.78	7.80	0.45	0.30	5.72	8.10	8.30
Selenium, µg/l	Both	50 (T)		110	108	1.00	20.00	10.50	10.50	13.44	9.50	128.0	15.25	19.05
Sodium	NCNS		1,000	110	0	28.00	933.0	305.0	154.5	315.2	120.5	103.4	484.3	880.7
Solids, Dissolved	NCNS		2,000	110	0	270.0	6,980	1,599	1,370	1,009	656.5	63.15	2,273	3,006
Sulfate			1,000	110	0	45.00	1,770	768.3	729.0	516.1	491.0	67.18	1,235	1,610
Vanadium, µg/l	HT; NN	100 (T; D)		110	107	10.00	14.00	12.00	12.00	2.83	2.00	23.57	13.00	13.80
Zinc	NCNS			110	81	0.01	0.58	0.09	0.03	0.14	0.02	162.04	0.05	0.38

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.10. Wepo Aquifer Wells, Northeast - (49, 54, 62R) Cumulative Water Quality Summary, 1980 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		60	54	0.04	0.10	0.06	0.05	0.03	0.01	45.40	0.09	0.10
Arsenic, µg/l	Both	200 (T)		60	52	0.50	2.00	1.31	1.50	0.75	0.50	57.37	2.00	2.00
Bicarbonate	NCNS			60	0	261.00	1,930.00	601.46	398.70	492.81	79.00	81.94	501.70	1,680.50
Boron, µg/l	NN	5,000		58	7	30.00	417.0	172.3	110.0	110.1	60.00	63.92	280.0	352.0
Cadmium, µg/l	Both	50 (T)		60	49	0.20	12.00	7.84	9.00	3.41	1.00	43.56	10.00	11.00
Calcium	NCNS			60	0	45.10	313.0	180.1	192.5	69.97	38.50	38.85	231.3	257.7
Chloride	NCNS			59	0	6.00	41.00	16.45	11.80	10.78	2.80	65.52	16.25	39.10
Chromium, µg/l	Both	1000 (T)		60	58	20.00	60.00	40.00	40.00	28.28	20.00	70.71	50.00	58.00
Conductivity	<1.5 x background (HT)	NCNS		46	0	1,510	3,950	2,175	1,755	653.1	200.0	30.03	2,745	3,173
Copper, µg/l	HT; NN	500 (T; D)		60	50	8.00	150.0	26.60	10.00	43.66	2.00	164.1	20.00	91.50
Fluoride	NCNS		2	60	0	0.16	4.60	0.95	0.30	1.52	0.10	159.9	0.40	4.41
Iron	NCNS			60	9	0.03	4.00	1.47	1.50	1.07	0.89	72.36	2.24	3.35
Lead, µg/l	Both	100 (T)		60	49	40.00	140.0	84.55	80.00	32.67	20.00	38.64	105.0	135.0
Magnesium	NCNS			60	0	9.70	130.0	84.45	94.25	34.82	9.70	41.23	104.0	120.1
Manganese	NCNS			60	0	0.04	0.73	0.24	0.27	0.15	0.13	62.33	0.37	0.42
Mercury, µg/l	HT	10 (T)		60	60	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	59	34	0.00	0.82	0.13	0.05	0.18	0.04	136.4	0.16	0.41
Nitrite as N	NCNS		100	58	48	0.00	1.23	0.13	0.01	0.39	0.01	302.5	0.01	0.69
NO3 + NO2	NN	0.132		26	16	0.05	0.44	0.19	0.19	0.12	0.08	65.18	0.23	0.38
pH	Both	6.5 – 9.0		48	0	6.90	8.40	7.81	7.70	0.44	0.40	5.69	8.23	8.40
Selenium, µg/l	Both	50 (T)		60	60	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium	NCNS		1,000	60	0	15.00	805.0	166.7	42.80	262.6	14.80	157.5	97.00	759.3
Solids, Dissolved	NCNS		2,000	60	0	706.0	2,641	1,488	1,406	359.1	67.00	24.14	1,501	2,202
Sulfate			1,000	59	0	264.0	1,050	637.9	690.0	183.2	109.0	28.72	772.0	821.8
Vanadium, µg/l	HT; NN	100 (T; D)		60	58	7.00	10.00	8.50	8.50	2.12	1.50	24.96	9.25	9.85
Zinc	NCNS			60	40	0.01	0.22	0.06	0.03	0.07	0.02	111.3	0.07	0.21

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.11. Wepo Aquifer Wells, Southeast - (66, 68) Cumulative Water Quality Summary, 1980 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		31	27	0.04	0.20	0.11	0.10	0.08	0.06	70.81	0.16	0.19
Arsenic, µg/l	Both	200 (T)		31	28	2.00	8.00	4.33	3.00	3.21	1.00	74.18	5.50	7.50
Bicarbonate	NCNS			32	0	591.00	1,895.88	1,088.15	1,037.27	303.39	133.50	27.88	1,269.10	1,520.34
Boron, µg/l	NN	5,000		30	4	30.00	480.0	245.3	255.0	88.98	55.00	36.28	297.5	359.5
Cadmium, µg/l	Both	50 (T)		32	27	13.00	23.00	18.00	20.00	4.30	3.00	23.90	20.00	22.40
Calcium	NCNS			32	0	2.70	542.0	195.8	216.0	152.4	128.45	77.81	278.5	460.0
Chloride	NCNS			32	0	9.80	74.00	43.22	47.50	17.00	10.30	39.33	50.25	69.01
Chromium, µg/l	Both	1000 (T)		31	28	10.00	20.00	13.33	10.00	5.77	0.00	43.30	15.00	19.00
Conductivity	<1.5 x background (HT)	NCNS		24	0	1,580	7,100	4,575	4,705	1,684	910.00	36.81	5,675	6,794
Copper, µg/l	HT; NN	500 (T; D)		31	25	10.00	160.0	38.33	15.00	59.81	5.00	156.01	20.00	125.0
Fluoride	NCNS		2	32	1	0.30	6.60	1.71	0.80	1.92	0.21	112.52	1.44	6.10
Iron	NCNS			32	6	0.04	2.07	0.75	0.60	0.63	0.40	84.16	1.26	1.97
Lead, µg/l	Both	100 (T)		32	24	0.20	200.0	137.2	160.0	68.91	30.00	50.23	180.0	197.0
Magnesium	NCNS			32	0	1.90	352.0	114.8	109.7	90.46	41.45	78.79	141.0	286.6
Manganese	NCNS			32	7	0.06	0.43	0.13	0.10	0.09	0.02	68.96	0.11	0.30
Mercury, µg/l	HT	10 (T)		32	32	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	NCNS		400	32	23	0.00	2.00	0.51	0.08	0.76	0.08	148.6	0.77	1.77
Nitrite as N	NCNS		100	31	20	0.00	2.28	0.36	0.03	0.72	0.02	203.5	0.25	1.63
NO3 + NO2	NN	0.132		13	11	0.57	2.28	1.43	1.43	1.21	0.86	84.85	1.85	2.19
pH	Both	6.5 – 9.0		26	0	7.00	8.80	7.76	7.75	0.57	0.40	7.40	8.00	8.78
Selenium, µg/l	Both	50 (T)		32	29	1.00	50.00	17.33	1.00	28.29	0.00	163.2	25.50	45.10
Sodium	NCNS		1,000	32	0	405.0	1,004	796.0	864.5	182.0	67.65	22.86	922.0	966.0
Solids, Dissolved	NCNS		2,000	32	0	980.0	5,660	3,571	3,927	1,316	371.0	36.86	4,162	5,479
Sulfate			1,000	31	0	251.0	3,140	1,841	1,962	826.2	313.5	44.88	2,227	3,056
Vanadium, µg/l	HT; NN	100 (T; D)		31	27	7.00	60.00	24.25	15.00	24.47	6.50	100.92	30.00	54.00
Zinc	NCNS			31	19	0.01	1.60	0.16	0.02	0.45	0.01	291.97	0.04	0.75

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Table WR-5.12. Wepo Aquifer Wells, Former Black Mesa Mine Area - (40, 43R, 44, 45, 46, 53, 58, 60) Cumulative Water Quality Summary, 1980 – 2014 [1]

Chemical Constituent	Livestock Water Quality Standard (NN: Navajo Nation, HT: Hopi Tribe)	Livestock Watering Criterion	Suggested Livestock Limits [2]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum	HT	5		182	148	0.04	1.00	0.23	0.10	0.26	0.06	112.75	0.36	0.75
Arsenic, µg/l	Both	200 (T)		181	153	0.30	30.00	2.31	1.00	5.48	0.45	237.37	2.00	3.00
Bicarbonate	NCNS			191	0	107.36	2,091.08	804.90	776.00	398.61	181.00	49.52	942.50	1,694.50
Boron, µg/l	NN	5,000		177	28	20.00	780.0	272.9	210.0	190.8	110.0	69.91	360.0	646.0
Cadmium, µg/l	Both	50 (T)		189	169	0.20	30.00	9.71	7.50	8.81	4.00	90.72	11.00	30.00
Calcium	NCNS			187	2	0.10	349.0	54.28	18.00	69.82	15.00	128.6	85.00	196.8
Chloride	NCNS			189	0	5.80	173.0	34.78	29.00	24.23	15.00	69.67	48.00	71.90
Chromium, µg/l	Both	1000 (T)		182	180	30.00	50.00	40.00	40.00	14.14	10.00	35.36	45.00	49.00
Conductivity	<1.5 x background (HT)	NCNS		151	0	750.0	7,400	2,783	2,350	1,625	950.0	58.40	3,850	5,800
Copper, µg/l	HT; NN	500 (T; D)		182	154	1.00	80.00	11.75	10.00	14.96	4.50	127.3	10.00	26.50
Fluoride	NCNS		2	191	3	0.10	22.70	4.41	1.53	4.29	1.34	97.23	8.03	11.93
Iron	NCNS			184	68	0.02	7.70	0.64	0.14	1.32	0.11	208.0	0.53	2.85
Lead, µg/l	Both	100 (T)		182	152	20.00	230.0	69.67	60.00	52.16	15.00	74.87	70.00	181.0
Magnesium	NCNS			188	17	0.50	585.0	43.68	9.10	75.75	8.25	173.4	63.75	157.0
Manganese	NCNS			183	23	0.01	2.31	0.17	0.08	0.33	0.06	200.5	0.17	0.45
Mercury, µg/l	HT	10 (T)		191	189	0.30	1.00	0.65	0.65	0.49	0.35	76.15	0.83	0.97
Nitrate as N	NCNS		400	190	104	0.00	86.01	3.72	0.11	12.84	0.08	345.6	0.26	33.18
Nitrite as N	NCNS		100	181	124	0.00	1.23	0.11	0.02	0.21	0.02	195.1	0.15	0.43
NO3 + NO2	NN	0.132		66	45	0.04	39.00	5.41	0.19	13.11	0.10	242.3	0.30	35.43
pH	Both	6.5 – 9.0		156	0	6.70	8.80	8.05	8.10	0.46	0.30	5.74	8.40	8.70
Selenium, µg/l	Both	50 (T)		191	178	1.00	408.0	71.85	8.00	120.1	7.00	167.2	80.00	280.8
Sodium	NCNS		1,000	191	1	44.00	1,436	515.0	472.0	334.9	192.0	65.04	677.00	1,241
Solids, Dissolved	NCNS		2,000	190	0	129.0	6,362	1,867	1,420	1,287	538.0	68.94	2,576	4,375
Sulfate			1,000	188	10	1.00	3,634	719.5	440.0	831.4	382.0	115.5	1,102	2,584
Vanadium, µg/l	HT; NN	100 (T; D)		182	174	10.00	500.0	73.75	10.00	172.4	0.00	233.7	15.00	335.5
Zinc	NCNS			181	121	0.01	0.59	0.06	0.04	0.09	0.02	148.6	0.06	0.20

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, N/A: Not Applicable, HT: Hopi Tribe, NN: Navajo Nation, NCNS: No Current Numeric Standard.

[2] Values in milligrams per liter, where published recommendations are available for constituents without existing criteria. Suggested guidance only; references vary. Sources: Raisbeck et al. 2008; Sigler and Kleehammer 2013.

Source: PWCC 2012 et seq.

Appendix WR-6

Additional Hydrogeology of Bedrock Units PWCC Leasehold and Surrounding Groundwater Study Area

This page intentionally left blank

Appendix WR-6. Additional Hydrogeology of Bedrock Units

As discussed in **Appendix WR-5**, the Wepo Formation is part of the Mesa Verde Group on Black Mesa, and is the source of the coal mined at KMC. In general, the Mesa Verde Group yields small amounts of water to wells, but it is an important source of numerous springs on Black Mesa. The aquifer has both confined and unconfined zones, and is discontinuous within the coal permit area and elsewhere across the mesa. Laterally, water-bearing zones are typically separated by incised streams, differences in rock characteristics, and local geologic structural deformations. The formations within the group intergrade or intertongue with each other and with the underlying Mancos Shale. These characteristics are further discussed in **Appendix WR-5**.

As depicted in Section 3.4 (**Figure 3.4-3**) of the main EIS text, the Mesa Verde Group is separated from the underlying D-Aquifer by the Mancos Shale. An intervening sandstone tongue of the Mesa Verde Group divides the Mancos Shale in the Four Corners region. In the Black Mesa area, only the lower part of the Mancos Shale is present, where it ranges in thickness from about 450 to 670 feet in the Black Mesa area (O'Sullivan et al. 1972). This marine-deposited formation is a major source of salinity in the Colorado River Basin, and is relatively impermeable.

In descending order, the following older stratigraphic units are present below the Wepo and Toreva formations:

- Mancos Shale
- Dakota Sandstone
- Morrison Formation /Cow Springs Sandstone
- Entrada Sandstone
- Carmel Formation
- Page Sandstone
- Navajo Sandstone
- Kayenta Formation
- Moenave Formation
- Wingate Sandstone
- Chinle Formation
- Moenkopi Formation
- Kaibab Limestone
- Coconino Sandstone
- Supai Formation
- Redwall Limestone
- Muav Limestone

In general, these stratigraphic units form a large set of asymmetrical, nested bowls with their deepest occurrences in the northwestern portion of the Black Mesa Basin (near the KMC leasehold), and their shallowest occurrences around the edges of the basin. This characteristic structure has the consequence that the outcrops of the major sequences form distorted rings or donut shapes in plan-view, as shown on **Figure WR-6.1, Surficial Geologic Map**. Isolated blocks of the higher sequences exist in areas to the northeast and northwest of Black Mesa. The individual sequences range in thickness from a few tens of feet to several hundred feet. A north-south generalized cross-section through the study area is shown on **Figure WR-6.2.** Note that the vertical exaggeration on **Figure WR-**

6.2 is large (26X), the actual dip of the rocks beneath Black Mesa is generally less than 2 degrees. The extents of the D- and N-Aquifers are depicted in **Figure WR-6.3**

The D-Aquifer consists of several formations as depicted in **Figure 3.4-3**. Water from the D aquifer typically has elevated TDS concentrations and is unsuitable for human consumption (Truini and Longsworth 2003). It is withdrawn only by windmills for livestock watering and by a few municipal wells for local household uses. In most of the study area, water from the D-Aquifer is generally separated from the underlying N-Aquifer by siltstone beds of the Carmel Formation. Although sandstone beds do occur within this formation, they are generally a minor part of the formation in the Black Mesa area. The Carmel Formation (and equivalents) typically forms a confining unit between the D- and N- aquifers (Truini and Longsworth 2003). However, south and southwest of the study area, the Carmel Formation is a somewhat coarser water-bearing unit. At NGS, the Carmel Formation is relatively thin (10 to 70 feet thick), but consists of extremely low permeability siltstone, claystone, and sandstone. It is underlain by the Page Sandstone, a 100- to 150-foot-thick unit overlying the Navajo Formation. At the plant site, N-Aquifer groundwater is present in unconfined conditions approximately 840 to 920 feet below ground surface (bgs).

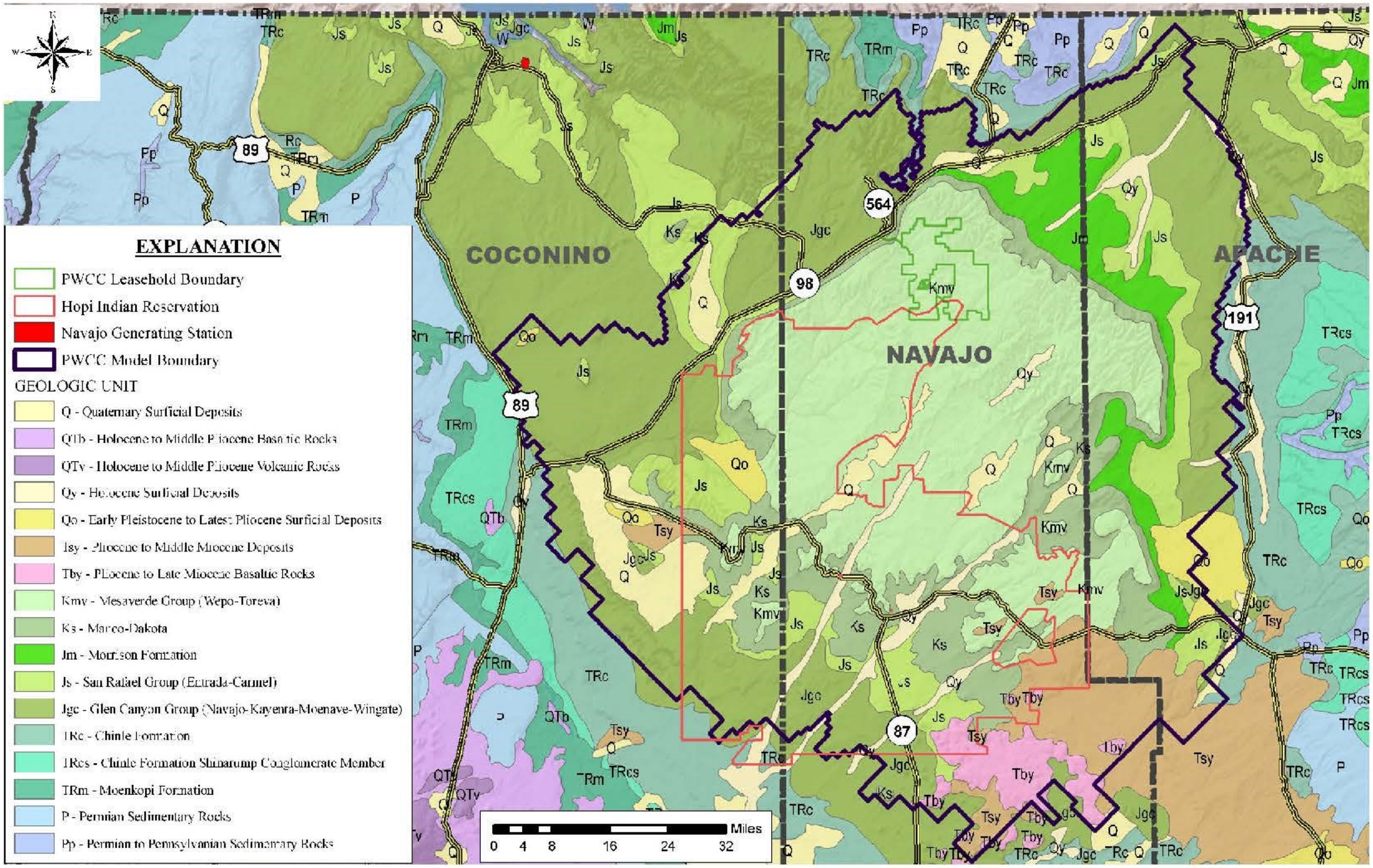
Leakage from the D aquifer to the N aquifer has been occurring in parts of the Black Mesa Basin for thousands of years (Truini and Longsworth 2003). Geographically, the group of wells apparently affected by this is in the southeastern part of Black Mesa, generally in the southeastern part of the Hopi Reservation. In that area, the N aquifer thins to extinction, the lateral flow velocity of water in the N aquifer was small before 1960, the D aquifer overlies the N aquifer, and hydraulic head in the D aquifer generally exceeds head in the N aquifer. The potential for induced leakage of poor-quality water from the D- to the N-Aquifer from ground-water development in the last several decades is a known concern. If induced leakage has or would occur, a recent investigation indicates that it could take centuries to geochemically detect it in that area. In addition, owing to the complex lithology of the D aquifer, it is difficult to specifically determine (forecast) where induced leakage to and degradation of the N-Aquifer would occur (Truini and Longsworth 2003).

General areas of known or likely leakage from the D-Aquifer to the N-Aquifer are indicated in Figure WR-6.4. Figure WR-6.5 indicates the continuity of the Carmel Formation from potential areas of leakage in the southern part of Black Mesa to the vicinity of the coal leases (Truini and Longsworth 2003).

The N-Aquifer is extensively used for water supply within the study region, since it generally contains good water quality and is extensive and relatively accessible. It is an important but finite resource for the Navajo and Hopi in this mostly arid environment. However, there are sites of uranium and trace metals contamination in the area from former uranium mining and milling operations. Groundwater remediation is taking place in the unconfined area of the N-Aquifer near Tuba City, where a plume of groundwater contamination has occurred from a former uranium mill operation (ADWR 2010b).

.

X:\0Projects\SRP_NGS_KMC_60298037\FIGs\DOCEIS\1_PDEIS\Letter_Sized\Water\FIG_WR_6_1_SurficialGeology.mxd

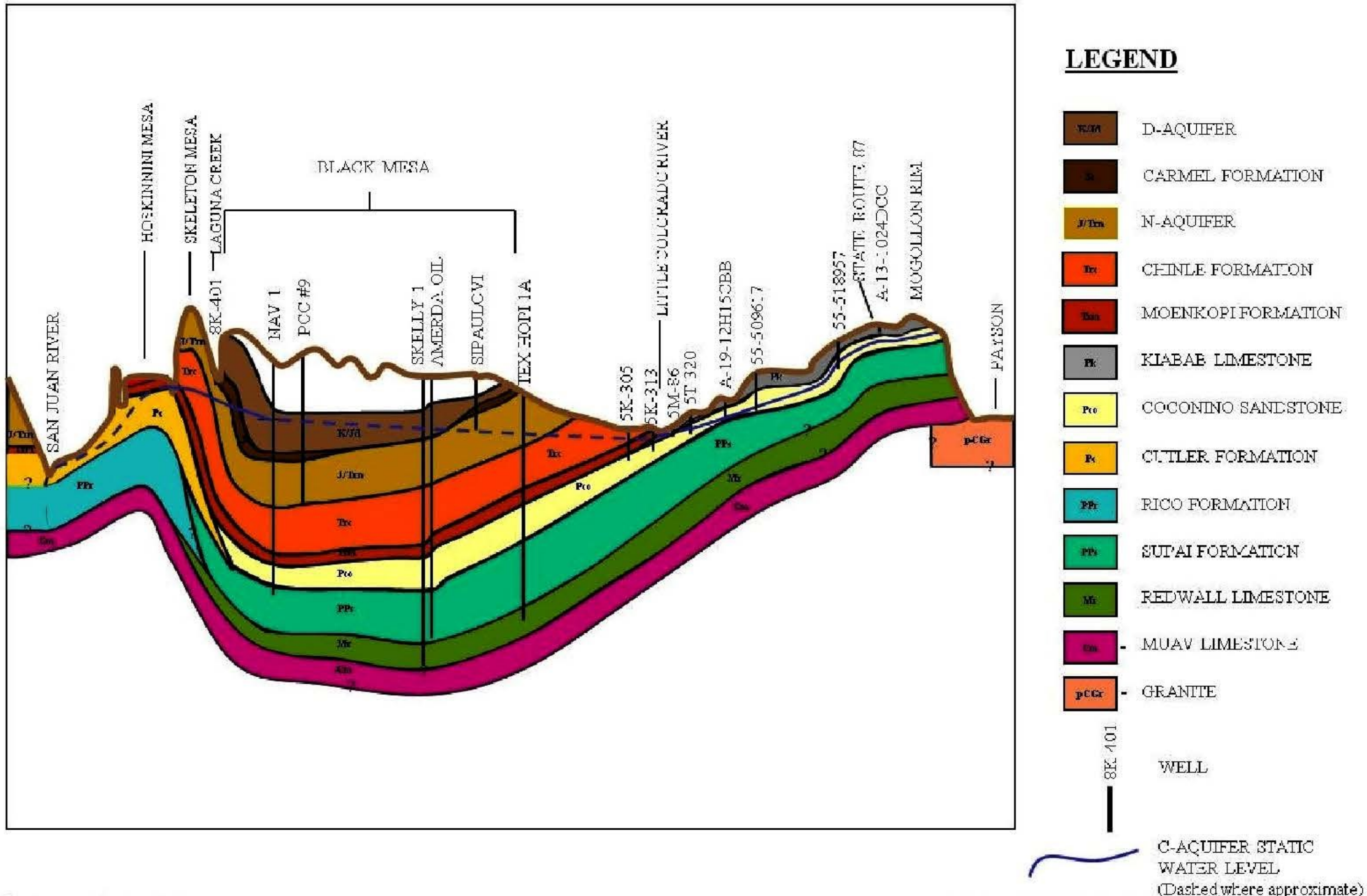


Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-6.1

Surficial Geology Map

7/20/2016



Vertical Exaggeration – 26X

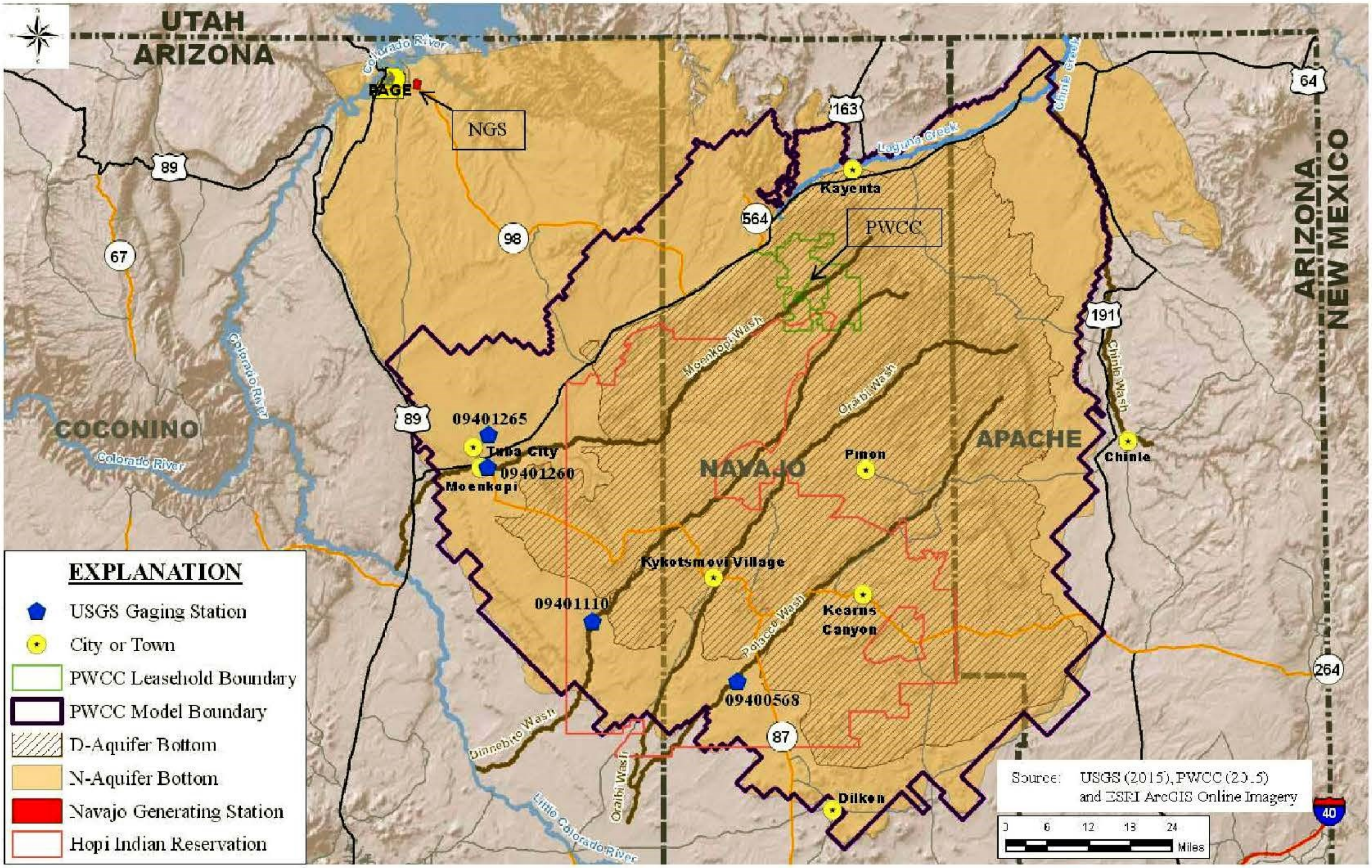
Source: HDR 2004

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

**Figure WR-6.2
North to South
Cross-Section**

N

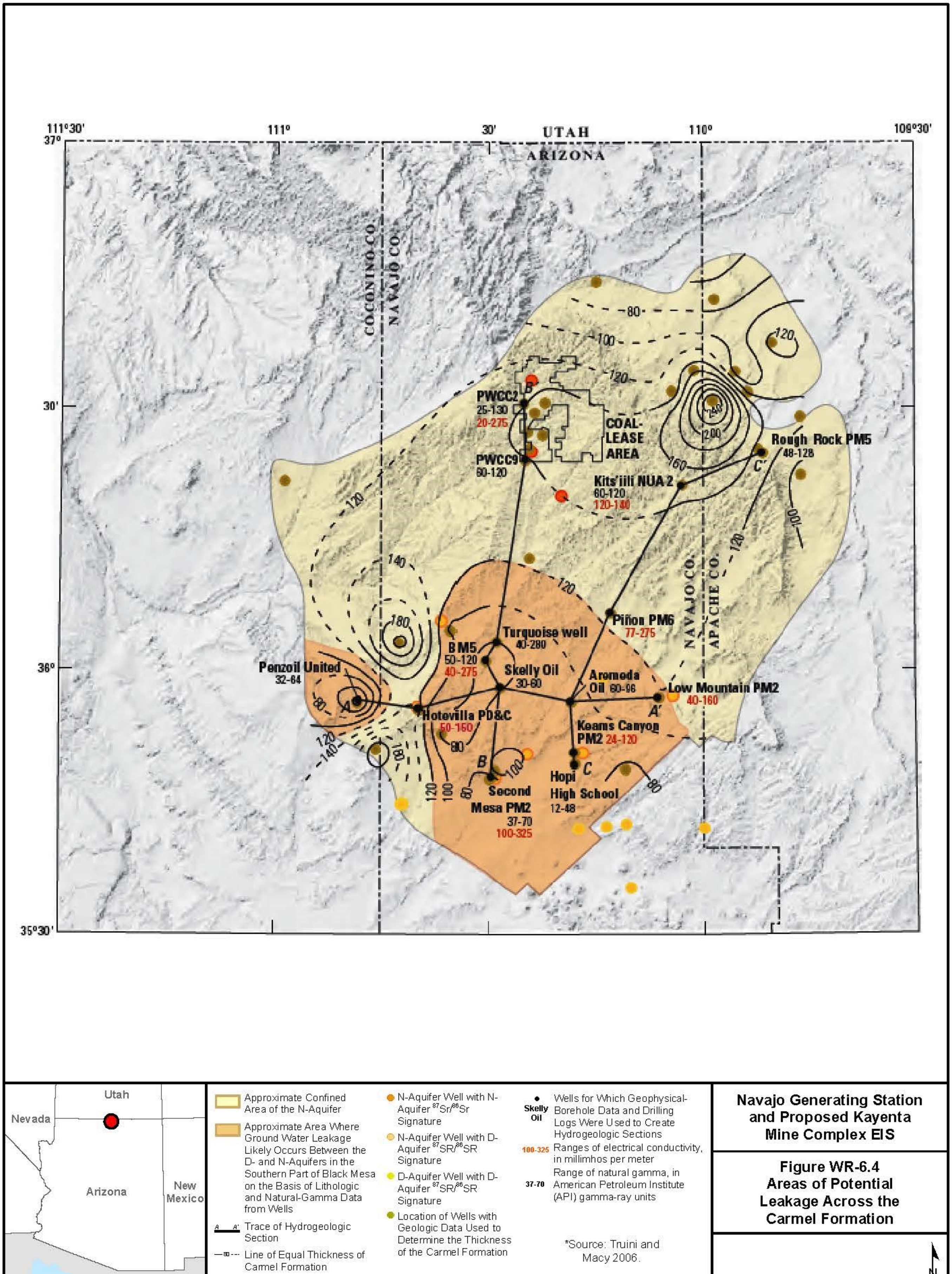
X:\0Projects\SRP_NGS_KMC_60298037\FIGs\DOCEIS\1_PDEIS\Letter_Sized\Water\FIG_WR_6_3_ExtentD&NAquifers.mxd



Navajo Generating Station
and Proposed Kayenta
Mine Complex EIS

Figure WR-6.3
Extent of D- and N-
Aquifers

7/20/2016



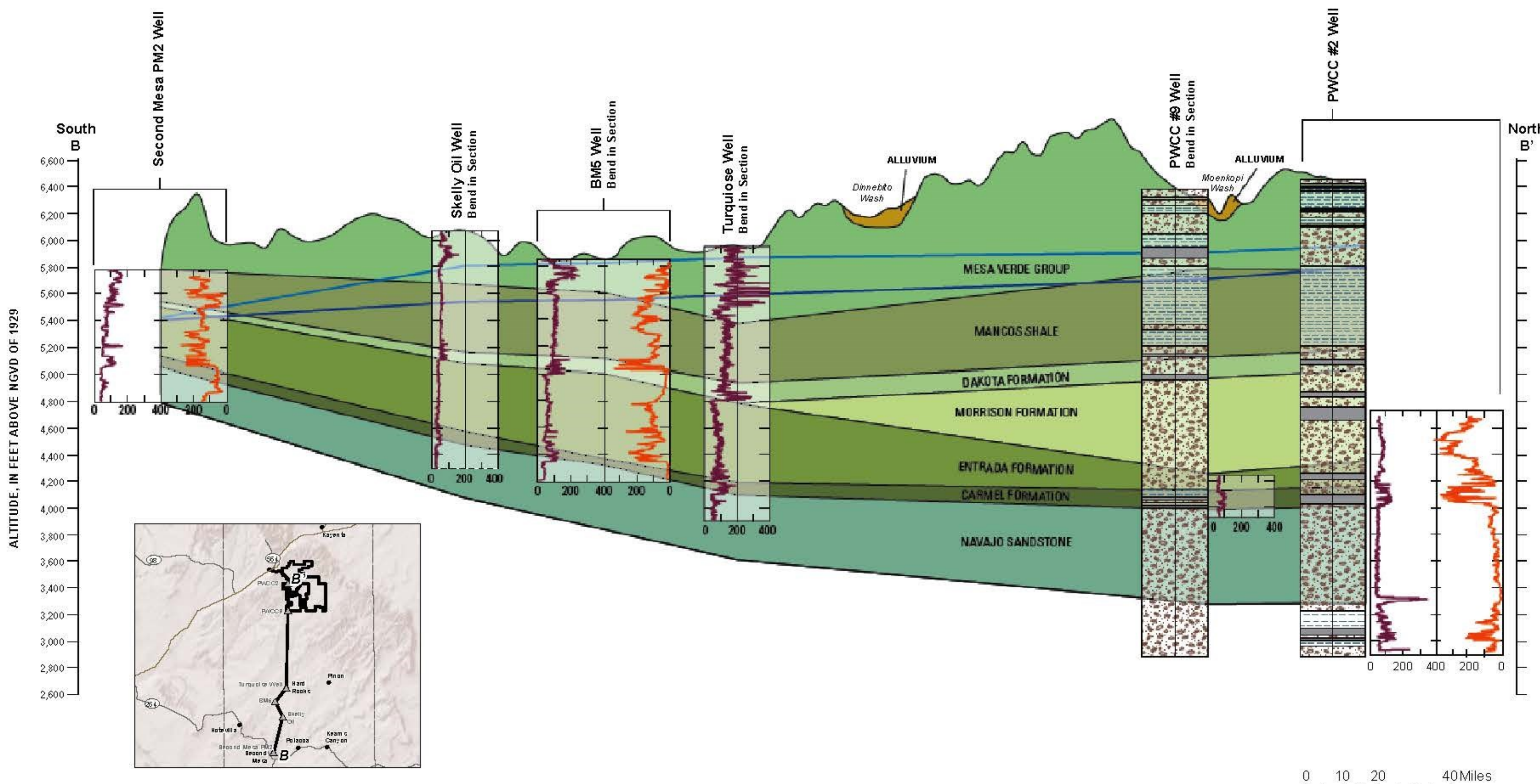
Navajo Generating Station and Proposed Kayenta Mine Complex EIS

**Figure WR-6.4
Areas of Potential Leakage Across the Carmel Formation**

7/20/2016

X:\0Projects\SRP_NGS_KMC_60298037\FIGs\DOC\EIS\1_PDEIS\Letter_Sized\Water\FIG_WR_6_5_ContinuityCarmelFormation.mxd

Section *B - B'* from Figure WR-6.4



- Mesa Verde Group
- Mancos Shale
- Dakota Formation
- Morrison Formation
- Entrada Formation
- Carmel Formation
- Navajo Sandstone
- 2002 Potentiometric Surface, D-Aquifer
- 2002 Potentiometric Surface, N-Aquifer

*Source: Truini and Macy 2006

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-6.5
Continuity of the Carmel Formation in the Project Vicinity

N

This page intentionally left blank

Appendix WR-7

N-Aquifer Pumping and Water Quality PWCC Leasehold

This page intentionally left blank

Table WR-7.1 Pumping Withdrawals from the N-Aquifer, Black Mesa Area, Northeastern Arizona, 1965-2011

Calendar Year	Industrial[1] (PWCC)	Municipal[2,3]		Total Withdrawals
		Confined	Unconfined	
1965	0	50	20	70
1966	0	110	30	140
1967	0	120	50	170
1968	100	150	100	350
1969	40	200	100	340
1970	740	280	150	1,170
1971	1,900	340	150	2,390
1972	3,680	370	250	4,300
1973	3,520	530	300	4,350
1974	3,830	580	360	4,770
1975	3,500	600	510	4,610
1976	4,180	690	640	5,510
1977	4,090	750	730	5,570
1978	3,000	830	930	4,760
1979	3,500	860	930	5,290
1980	3,540	910	880	5,330
1981	4,010	960	1,000	5,970
1982	4,740	870	960	6,570
1983	4,460	1,360	1,280	7,100
1984	4,170	1,070	1,400	6,640
1985	2,520	1,040	1,160	4,720
1986	4,480	970	1,260	6,710
1987	3,830	1,130	1,280	6,240
1988	4,090	1,250	1,310	6,650
1989	3,450	1,070	1,400	5,920
1990	3,430	1,170	1,210	5,810
1991	4,020	1,140	1,300	6,460
1992	3,820	1,180	1,410	6,410
1993	3,700	1,250	1,570	6,520
1994	4,080	1,210	1,600	6,890
1995	4,340	1,220	1,510	7,070
1996	4,010	1,380	1,650	7,040
1997	4,130	1,380	1,580	7,090
1998	4,030	1,440	1,590	7,060
1999	4,210	1,420	1,480	7,110
2000	4,490	1,610	1,640	7,740
2001	4,530	1,490	1,660	7,680
2002	4,640	1,500	1,860	8,000

Table WR-7.1 Pumping Withdrawals from the N-Aquifer, Black Mesa Area, Northeastern Arizona, 1965-2011

Calendar Year	Industrial[1] (PWCC)	Municipal[2,3]		Total Withdrawals
		Confined	Unconfined	
2003	4,450	1,350	1,440	7,240
2004	4,370	1,240	1,600	7,210
2005	4,480	1,280	1,570	7,330
2006	1,200	1,300 [4]	1,600 [4]	4,100 [4]
2007	1,170	1,460	1,640	4,270
2008	1,210	1,430 [5,6]	1,560 [5]	4,200 [6]
2009	1,390	1,440	1,400	4,230
2010	1,170	1,450 [4]	1,420	4,040 [4]
2011	1,390	1,460 [4]	1,630	4,480 [4]

[1] Metered pumpage from the confined part of the aquifer by Peabody Western Coal Company.

[2] Does not include withdrawals from the wells equipped with windmills.

[3] Includes estimated pumpage 1965-73 and metered pumpage 1974-79 at Tuba City; metered pumpage at Kayenta and estimated pumpage at Chilchinbito, Rough Rock, Pinon, Kearns Canyon, and Kykotsmovi before 1980; metered and estimated pumpage furnished by the Navajo Tribal Utility Authority and the Bureau of Indian Affairs and collected by the U.S. Geological Survey, 1980-85; and metered pumpage furnished by the Navajo tribal Utility Authority, the Bureau of Indian Affairs, various Hopi Village Administrations, and the U.S. Geological Survey, 1986-2011.

[4] Navajo Tribal Utility Authority meter data were incomplete; therefore, municipal withdrawals are estimated, and total withdrawal uses an estimation in the calculation.

[5] Confined and unconfined totals were reversed in previous reports.

[6] Confined withdrawals are about 90 acre-feet greater than previously reported.

Note: Values are rounded to nearest 10 acre-feet. Data for 1965-79 from Eychaner (1983). Total withdrawals in Littin and Monroe (1996) were for the confined area of the aquifer.

Table WR-7.2. Navajo Aquifer Wells (combined NAV2 through NAV9) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water MCL [3]	Public Drinking Water MCL [4]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	66	39	0.0043	0.07	0.02	0.01	0.02	0.006	79.54	0.04	0.07
Arsenic, µg/l (T)	10 µg /l		76	0	1	4.2	2.99	3.00	0.66	0.3	22.01	3.30	4.00
Bicarbonate			79	0	66	129	85.47	80.00	14.79	7.0	17.31	93.50	115.30
Boron, µg/l			78	11	17.52	50	27.10	20.00	8.89	2.0	32.82	30.00	42.10
Cadmium, µg/l (T)	5 µg /l		75	74	6	6	6.00	6.00	N/A	N/A	N/A	6.00	6.00
Calcium			78	0	2.5	26.4	6.40	3.85	6.72	0.55	104.93	4.38	26.00
Chloride		250 mg/l	79	4	2.0	5.0	3.20	3.00	1.11	1.0	34.66	4.00	5.00
Chromium, µg/l (T)	100 µg /l		64	60	0.651	6	2.27	1.21	2.52	0.4605	111.26	2.68	5.34
Conductivity			79	0	143	484	234.33	187.00	93.10	30	39.73	241.00	473.00
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	75	73	0.337	7.671	4.00	4.00	5.19	3.667	129.52	5.84	7.30
Fluoride	4 mg/l	2 mg/l	79	24	0.100	0.300	0.203	0.200	0.03	0.000	15.83	0.20	0.27
Iron		0.3 mg/l	78	72	0.003	0.040	0.016	0.010	0.02	0.005	91.72	0.03	0.04
Lead, µg/l (T)	15 µg /l		76	66	0.10	60.00	6.32	0.35	18.86	0.173	298.20	0.55	33.40
Magnesium			78	64	0.05	4.00	2.18	3.00	1.76	0.950	80.80	3.80	3.94
Manganese		0.05 mg/l	78	75	0.001	0.010	0.007	0.009	0.01	0.001	78.96	0.010	0.010
Mercury, µg/l (T)	2 µg /l		76	74	0.010	0.020	0.015	0.015	0.01	0.005	47.14	0.018	0.020
Nitrate as N	10 mg /l		79	0	0.620	1.750	0.930	0.870	0.27	0.090	29.11	0.96	1.63
Nitrite as N	1 mg /l		79	79	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2			79	0	0.62	1.75	0.92	0.86	0.27	0.09	29.14	0.95	1.63
pH		6.5 – 8.5	79	0	8.2	9.5	8.98	9.00	0.32	0.2	3.62	9.20	9.40
Selenium, µg/l (T)	50 µg /l		76	66	0.3624	4	2.82	3.00	1.28	0.55	45.43	3.78	4.00
Sodium			78	0	26	72	45.48	39.40	14.10	8.75	31.00	50.48	69.25
Solids, Dissolved		500 mg/l	79	0	80.0	315.0	151.0	130.0	60.3	22.0	39.9	170.0	310.0
Sulfate		250 mg/l	79	1	1.39	127.21	22.41	8.67	32.88	5.74	146.68	16.81	114.45
Vanadium, µg/l (T)			34	0	8.0	20.0	12.60	12.50	3.54	3.5	28.09	15.75	18.35
Zinc (T)		5 mg/l	34	32	0.0005	0.007	0.004	0.004	0.005	0.00325	122.57	0.005	0.007

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). Blank cells mean there are no relevant criteria for the use listed. ND=Not Detected; N/A=Not Applicable

[2] Units as reported in PWCC laboratory analyses. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l)

[3] Criteria reflect total (non-filtered) units in published regulations for publically-owned systems. Criteria are Primary MCLs (Maximum Contaminant Levels) except where noted. Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

[4] Secondary MCLs (Maximum Contaminant Levels): the maximum (as total or non-filtered) level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq.

Table WR-7.3. Navajo Aquifer Well (NAV2) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water MCL [3]	Public Drinking Water MCL [4]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	9	4	0.00	0.06	0.02	0.01	0.02	0.00	127.29	0.01	0.05
Arsenic, µg/l (T)	10 µg /l		9	0	2.50	3.30	2.90	3.00	0.23	0.10	8.09	3.00	3.18
Bicarbonate			9	0	71.0	81.0	74.7	74.0	3.2	2.0	4.29	76	80
Boron, µg/l			9	5	17.5	24.0	20.4	20.0	2.7	1.2	13.16	21	23
Cadmium, µg/l (T)	5 µg /l		9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium			9	0	8.0	9.6	8.7	8.7	0.6	0.7	7.18	9	10
Chloride		250 mg/l	9	0	2.00	2.00	2.00	2.00	0.00	0.00	0.00	2.00	2.00
Chromium, µg/l (T)	100 µg /l		9	7	0.65	6.00	3.33	3.33	3.78	2.67	113.74	4.66	5.73
Conductivity			9	0	157.0	164.0	160.9	160.0	2.5	2.0	1.54	163	164
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	9	8	0.34	0.34	0.34	0.34	N/A	N/A	N/A	0.34	0.34
Fluoride	4 mg/l	2 mg/l	9	5	0.10	0.20	0.15	0.15	0.06	0.05	38.49	0.20	0.20
Iron		0.3 mg/l	9	7	0.00	0.01	0.01	0.01	0.00	0.00	73.95	0.01	0.01
Lead, µg/l (T)	15 µg /l		9	7	0.15	60.00	30.08	30.08	42.32	29.92	140.70	45.04	57.01
Magnesium			9	7	0.11	0.15	0.13	0.13	0.02	0.02	18.81	0.14	0.15
Manganese		0.05 mg/l	9	8	0.01	0.01	0.01	0.01	N/A	N/A	N/A	0.01	0.01
Mercury, µg/l (T)	2 µg /l		9	8	0.02	0.02	0.02	0.02	N/A	N/A	N/A	0.02	0.02
Nitrate as N	10 mg /l		9	0	0.87	1.09	0.96	0.95	0.07	0.02	6.91	0.95	1.07
Nitrite as N	1 mg /l		9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2			9	0	0.81	1.09	0.93	0.94	0.08	0.01	8.11	0.95	1.03
pH		6.5 – 8.5	9	0	8.40	8.80	8.67	8.70	0.14	0.10	1.63	8.80	8.80
Selenium, µg/l (T)	50 µg /l		9	7	0.36	0.74	0.55	0.55	0.26	0.19	48.10	0.64	0.72
Sodium			9	0	26.0	29.4	27.2	26.8	1.4	0.8	5.27	28	29
Solids, Dissolved		500 mg/l	9	0	99.0	120.0	106.3	108.0	7.1	8.0	6.68	110	116
Sulfate		250 mg/l	9	0	4.29	8.00	6.70	7.00	1.27	0.46	18.96	7.46	8.00
Vanadium, µg/l (T)			9	0	8.00	14.00	9.54	9.00	1.94	1.00	20.30	10.00	12.80
Zinc (T)		5 mg/l	9	8	0.00	0.00	0.00	0.00	N/A	N/A	N/A	0.00	0.00

1 All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). Blank cells mean there are no relevant criteria for the use listed. ND=Not Detected; N/A=Not Applicable

2 Units as reported in PWCC laboratory analyses. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l)

3 Criteria reflect total (non-filtered) units in published regulations for publically-owned systems. Criteria are Primary MCLs (Maximum Contaminant Levels) except where noted. Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

4 Secondary MCLs (Maximum Contaminant Levels): the maximum (as total or non-filtered) level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq.

Table WR-7.4. Navajo Aquifer Well (NAV3) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water Criterion [3]	Public Drinking Water Criterion [4]	Domestic Drinking Water Criterion [5]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	NCNS	10	5	0.01	0.04	0.02	0.02	0.01	0.01	55.54	0.04	0.04
Arsenic, µg/l (T)	10 µg /l		10	10	0	2.10	3.80	3.17	3.20	0.49	0.25	15.53	3.38	3.80
Bicarbonate				11	0	75.0	88.0	78.5	77.0	4.0	2.0	5.05	80	85
Boron, µg/l			630	11	1	20.0	30.0	23.0	20.0	4.8	0.0	21.00	28	30
Cadmium, µg/l (T)	5 µg /l		5	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium				11	0	3.9	4.4	4.2	4.2	0.1	0.1	3.44	4.3	4.4
Chloride		250 mg/l		11	0	2.0	3.0	2.7	3.0	0.5	0.0	17.00	3.0	3.0
Chromium, µg/l (T)	100 µg /l		100	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity				11	0	177.0	187.0	183.4	185.0	3.2	2.0	1.73	186	187
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	1,300	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	4 mg/l	2 mg/l	4,000	11	0	0.20	0.30	0.21	0.20	0.03	0.00	14.73	0.20	0.27
Iron		0.3 mg/l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	15 µg /l		15	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium				11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Manganese		0.05 mg/l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Mercury, µg/l (T)	2 µg /l		2	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	10 mg /l		10,000	11	0	0.78	0.91	0.84	0.84	0.04	0.02	4.69	0.86	0.90
Nitrite as N	1 mg /l		1,000	11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2				11	0	0.71	0.88	0.82	0.82	0.05	0.04	5.90	0.86	0.87
pH		6.5 – 8.5	5.0 – 9.0	11	0	8.80	9.20	9.01	9.00	0.12	0.10	1.36	9.05	9.20
Selenium, µg/l (T)	50 µg /l		50	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium				11	0	36.20	40.50	37.75	37.60	1.21	0.60	3.22	37.90	39.90
Solids, Dissolved		500 mg/l		11	0	80.0	130.0	115.1	120.0	14.7	10.0	12.8	123.0	130.0
Sulfate		250 mg/l		11	0	5.14	9.24	7.21	7.20	0.95	0.20	13.17	7.33	8.54
Vanadium, µg/l (T)			NCNS	10	1	8.0	13.0	10.3	11.0	1.9	2.0	18.1	12.0	12.6
Zinc (T)		5 mg/l	2,100	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND

1 All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected, NCNS: No Current Numeric Standard. N/A: Not Applicable

2 Units as reported in PWCC laboratory analyses.

3 Criteria reflect units in published regulations for publically-owned systems. Criteria are Primary MCLs except where noted: Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

4 Secondary MCLs: the maximum level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq. (Data).

Table WR-7.5. Navajo Aquifer Well (NAV4) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water MCL [3]	Public Drinking Water MCL [4]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	8	4	0.01	0.04	0.01	0.01	0.02	0.00	117.24	0.01	0.03
Arsenic, µg/l (T)	10 µg /l		8	0	2.40	3.30	2.93	2.95	0.32	0.25	11.08	3.20	3.27
Bicarbonate			8	0	76.0	103.0	87.0	86.5	9.4	7.0	10.78	93	100
Boron, µg/l			8	0	20.0	30.0	22.5	20.0	4.6	0.0	20.57	23	30
Cadmium, µg/l (T)	5 µg /l		8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium			8	0	3.40	4.60	3.96	3.95	0.43	0.35	10.87	4.25	4.53
Chloride		250 mg/l	8	0	4.00	5.00	4.13	4.00	0.35	0.00	8.57	4.00	4.65
Chromium, µg/l (T)	100 µg /l		8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity			8	0	220.0	241.0	232.0	231.0	8.0	7.5	3.44	240	241
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	4 mg/l	2 mg/l	8	3	0.200	0.200	0.200	0.200	0.000	0.000	0.000	0.200	0.200
Iron		0.3 mg/l	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	15 µg /l		8	5	0.200	0.900	0.500	0.400	0.361	0.200	72.111	0.650	0.850
Magnesium			8	7	0.500	0.500	0.500	0.500	N/A	N/A	N/A	0.500	0.500
Manganese		0.05 mg/l	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Mercury, µg/l (T)	2 µg /l		8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	10 mg /l		8	0	0.89	1.05	0.96	0.95	0.05	0.02	5.58	0.98	1.04
Nitrite as N	1 mg /l		8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2			8	0	0.89	1.05	0.96	0.95	0.05	0.02	5.58	0.98	1.04
pH		6.5 – 8.5	8	0	8.60	9.40	9.14	9.20	0.25	0.10	2.74	9.30	9.37
Selenium, µg/l (T)	50 µg /l		8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium			8	0	44.60	50.40	48.23	48.25	1.92	1.45	3.97	49.73	50.30
Solids, Dissolved		500 mg/l	8	0	150.00	160.00	151.25	150.00	3.54	0.00	2.34	150.00	156.50
Sulfate		250 mg/l	8	0	14.38	15.60	15.03	15.10	0.47	0.40	3.11	15.36	15.57
Vanadium, µg/l (T)			8	0	12.00	20.00	14.63	13.50	2.92	1.50	20.00	15.75	19.30
Zinc (T)		5 mg/l	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND

1 All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). Blank cells mean there are no relevant criteria for the use listed. ND=Not Detected; N/A=Not Applicable

2 Units as reported in PWCC laboratory analyses. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l)

3 Criteria reflect total (non-filtered) units in published regulations for publically-owned systems. Criteria are Primary MCLs (Maximum Contaminant Levels) except where noted. Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

4 Secondary MCLs (Maximum Contaminant Levels): the maximum (as total or non-filtered) level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq. (Data).

Table WR-7.6. Navajo Aquifer Well (NAV5) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water MCL [3]	Public Drinking Water MCL [4]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	10	7	0.01	0.07	0.03	0.01	0.03	0.00	111.27	0.04	0.06
Arsenic, µg/l (T)	10 µg /l		10	0	2.40	3.40	2.79	2.75	0.29	0.15	10.48	2.88	3.27
Bicarbonate			11	0	91.0	104.0	95.8	95.0	3.9	3.0	4.09	98	102
Boron, µg/l			10	0	30.0	40.0	37.0	40.0	4.8	0.0	13.06	40	40
Cadmium, µg/l (T)	5 µg /l		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium			10	0	2.50	2.80	2.68	2.70	0.10	0.10	3.85	2.78	2.80
Chloride		250 mg/l	11	0	4.70	5.00	4.97	5.00	0.09	0.00	1.82	5.00	5.00
Chromium, µg/l (T)	100 µg /l		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity			11	0	293.0	315.0	302.2	302.0	5.9	3.0	1.96	304	312
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	4 mg/l	2 mg/l	11	0	0.20	0.30	0.22	0.20	0.04	0.00	18.68	0.23	0.30
Iron		0.3 mg/l	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	15 µg /l		10	9	0.40	0.40	0.40	0.40	N/A	N/A	N/A	0.40	0.40
Magnesium			10	9	0.30	0.30	0.30	0.30	N/A	N/A	N/A	0.30	0.30
Manganese		0.05 mg/l	10	9	0.01	0.01	0.01	0.01	N/A	N/A	N/A	0.01	0.01
Mercury, µg/l (T)	2 µg /l		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	10 mg /l		11	0	0.87	1.07	0.96	0.97	0.07	0.07	7.49	1.02	1.06
Nitrite as N	1 mg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2			11	0	0.87	1.07	0.96	0.96	0.07	0.07	7.42	1.02	1.06
pH		6.5 – 8.5	11	0	9.20	9.50	9.36	9.40	0.10	0.10	1.10	9.40	9.50
Selenium, µg/l (T)	50 µg /l		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium			10	0	62.8	68.7	66.2	66.4	2.0	1.8	2.95	67.7	68.6
Solids, Dissolved		500 mg/l	11	0	170.0	200.0	188.9	190.0	10.6	10.0	5.63	200.0	200.0
Sulfate		250 mg/l	11	0	24.1	30.0	25.5	25.0	1.7	0.6	6.57	25.4	28.4
Vanadium, µg/l (T)			10	0	10.0	23.0	14.2	13.0	4.4	3.0	31.28	16.0	21.7
Zinc (T)		5 mg/l	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). Blank cells mean there are no relevant criteria for the use listed. ND=Not Detected; N/A=Not Applicable

[2] Units as reported in PWCC laboratory analyses. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l)

[3] Criteria reflect total (non-filtered) units in published regulations for publically-owned systems. Criteria are Primary MCLs (Maximum Contaminant Levels) except where noted. Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

[4] Secondary MCLs (Maximum Contaminant Levels): the maximum (as total or non-filtered) level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq. (Data).

Table WR-7.7. Navajo Aquifer Well (NAV6) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water MCL [3]	Public Drinking Water MCL [4]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	11	6	0.01	0.07	0.02	0.01	0.03	0.00	102.34	0.02	0.06
Arsenic, µg/l (T)	10 µg /l		11	0	3.60	4.20	3.88	3.90	0.16	0.10	4.12	3.95	4.10
Bicarbonate			11	0	69.0	87.0	78.5	79.0	5.4	4.0	6.84	81.5	86.0
Boron, µg/l			11	2	20.0	30.0	23.6	20.0	4.9	0.0	20.70	30.0	30.0
Cadmium, µg/l (T)	5 µg /l		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium			11	0	3.8	4.1	3.9	3.9	0.1	0.1	3.0	4.0	4.1
Chloride		250 mg/l	11	4	2.0	3.0	2.1	2.0	0.4	0.0	17.6	2.0	2.7
Chromium, µg/l (T)	100 µg /l		11	10	0.8	0.8	0.8	0.8	N/A	N/A	N/A	0.8	0.8
Conductivity			11	0	143.0	191.0	175.2	175.0	12.1	2.0	6.93	180	189
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	4 mg/l	2 mg/l	11	7	0.20	0.20	0.20	0.20	0.00	0.00	0.00	0.20	0.20
Iron		0.3 mg/l	11	10	0.04	0.04	0.04	0.04	N/A	N/A	N/A	0.04	0.04
Lead, µg/l (T)	15 µg /l		11	8	0.10	0.60	0.30	0.20	0.27	0.10	89.09	0.40	0.56
Magnesium			11	9	0.05	0.40	0.22	0.22	0.25	0.18	112.31	0.31	0.38
Manganese		0.05 mg/l	11	10	0.00	0.00	0.00	0.00	N/A	N/A	N/A	0.00	0.00
Mercury, µg/l (T)	2 µg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	10 mg /l		11	0	0.62	0.70	0.66	0.67	0.03	0.02	4.28	0.69	0.70
Nitrite as N	1 mg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2			11	0	0.62	0.70	0.66	0.67	0.03	0.02	4.28	0.69	0.70
pH		6.5 – 8.5	11	0	8.80	9.20	9.00	9.00	0.13	0.10	1.49	9.10	9.20
Selenium, µg/l (T)	50 µg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium			11	0	36.0	39.5	37.3	37.1	1.2	1.0	3.33	38.1	39.3
Solids, Dissolved		500 mg/l	11	0	100.0	130.0	113.5	110.0	8.5	6.0	7.49	120.0	125.0
Sulfate		250 mg/l	11	0	4.8	8.1	6.3	6.1	0.8	0.3	12.91	6.6	7.4
Vanadium, µg/l (T)			11	0	9.0	17.0	12.6	12.0	2.5	2.0	19.47	14.0	16.5
Zinc (T)		5 mg/l	11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). Blank cells mean there are no relevant criteria for the use listed. ND=Not Detected; N/A=Not Applicable

[2] Units as reported in PWCC laboratory analyses. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l)

[3] Criteria reflect total (non-filtered) units in published regulations for publically-owned systems. Criteria are Primary MCLs (Maximum Contaminant Levels) except where noted. Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

[4] Secondary MCLs (Maximum Contaminant Levels): the maximum (as total or non-filtered) level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq. (Data).

Table WR-7.8. Navajo Aquifer Well (NAV7) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water MCL [3]	Public Drinking Water MCL [4]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	11	8	0.00	0.04	0.02	0.01	0.02	0.00	113.84	0.00	0.04
Arsenic, µg/l (T)	10 µg /l		11	0	2.5	4.2	3.2	3.1	0.5	0.3	16.7	3.4	4.10
Bicarbonate			11	0	73.0	125.0	83.2	79.0	14.5	3.0	17.4	81.7	106.5
Boron, µg/l			11	2	20.0	30.0	25.6	30.0	5.3	0.0	20.6	30.0	30.00
Cadmium, µg/l (T)	5 µg /l		11	10	6.00	6.00	6.00	6.00	N/A	N/A	N/A	6.00	6.00
Calcium			11	0	2.50	3.40	3.02	3.10	0.26	0.10	8.74	3.20	3.30
Chloride		250 mg/l	11	0	3.00	3.60	3.05	3.00	0.18	0.00	5.92	3.00	3.30
Chromium, µg/l (T)	100 µg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity			11	0	216.0	237.0	229.6	230.0	6.0	4.0	2.61	233	237.0
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	4 mg/l	2 mg/l	11	3	0.19	0.20	0.20	0.20	0.00	0.00	1.78	0.20	0.20
Iron		0.3 mg/l	11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	15 µg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium			11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Manganese		0.05 mg/l	11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Mercury, µg/l (T)	2 µg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	10 mg /l		11	0	0.73	0.95	0.83	0.82	0.07	0.02	8.36	0.86	0.94
Nitrite as N	1 mg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2			11	0	0.70	0.95	0.82	0.81	0.08	0.03	9.54	0.84	0.94
pH		6.5 – 8.5	11	0	9.00	9.40	9.23	9.20	0.13	0.10	1.38	9.30	9.40
Selenium, µg/l (T)	50 µg /l		11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium			11	0	45.6	51.8	49.0	48.7	1.7	1.4	3.56	50.3	51.2
Solids, Dissolved		500 mg/l	11	0	130.0	170.0	151.8	150.0	12.5	10.0	8.24	160.0	170.0
Sulfate		250 mg/l	11	0	14.7	16.9	15.9	16.1	0.7	0.4	4.50	16.5	16.7
Vanadium, µg/l (T)			11	0	11.0	20.0	17.0	18.0	3.0	2.0	17.65	19.5	20.0
Zinc (T)		5 mg/l	11	11	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). Blank cells mean there are no relevant criteria for the use listed. ND=Not Detected; N/A=Not Applicable

[2] Units as reported in PWCC laboratory analyses. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l)

[3] Criteria reflect total (non-filtered) units in published regulations for publically-owned systems. Criteria are Primary MCLs (Maximum Contaminant Levels) except where noted. Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

[4] Secondary MCLs (Maximum Contaminant Levels): the maximum (as total or non-filtered) level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq. (Data).

Table WR-7.9. Navajo Aquifer Well (NAV8) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water MCL [3]	Public Drinking Water MCL [4]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	8	6	0.00	0.04	0.02	0.02	0.03	0.02	121.69	0.03	0.04
Arsenic, µg/l (T)	10 µg /l		8	0	1.00	2.30	1.74	1.80	0.42	0.20	24.02	2.00	2.20
Bicarbonate			8	0	110.0	129.0	117.3	114.0	7.6	3.0	6.51	120.8	129.0
Boron, µg/l			8	0	20.0	50.0	40.3	41.5	10.6	8.0	26.39	49.3	50.0
Cadmium, µg/l (T)	5 µg /l		8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium			8	0	23.0	26.4	25.5	26.0	1.2	0.1	4.70	26.03	26.30
Chloride		250 mg/l	8	0	4.0	5.0	4.3	4.0	0.5	0.0	10.89	4.25	5.00
Chromium, µg/l (T)	100 µg /l		8	7	1.6	1.6	1.6	1.6	N/A	N/A	N/A	1.57	1.57
Conductivity			8	0	459.0	484.0	472.9	473.0	7.0	2.5	1.49	475.5	481.6
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	8	7	7.7	7.7	7.7	7.7	N/A	N/A	N/A	7.7	7.7
Fluoride	4 mg/l	2 mg/l	8	4	0.20	0.20	0.20	0.20	0.00	0.00	0.00	0.20	0.20
Iron		0.3 mg/l	8	5	0.01	0.03	0.02	0.01	0.01	0.01	79.42	0.02	0.03
Lead, µg/l (T)	15 µg /l		8	7	0.30	0.30	0.30	0.30	N/A	N/A	N/A	0.30	0.30
Magnesium			8	0	3.00	4.00	3.63	3.80	0.40	0.15	11.11	3.90	3.97
Manganese		0.05 mg/l	8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Mercury, µg/l (T)	2 µg /l		8	7	0.01	0.01	0.01	0.01	N/A	N/A	N/A	0.01	0.01
Nitrate as N	10 mg /l		8	0	1.53	1.75	1.66	1.65	0.07	0.02	4.37	1.69	1.75
Nitrite as N	1 mg /l		8	8	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2			8	0	1.53	1.75	1.64	1.63	0.06	0.03	3.87	1.67	1.72
pH		6.5 – 8.5	8	0	8.20	8.50	8.33	8.35	0.12	0.10	1.40	8.40	8.47
Selenium, µg/l (T)	50 µg /l		8	0	3.0	4.0	3.4	3.1	0.5	0.1	15.01	4.0	4.0
Sodium			8	0	67.0	72.0	69.9	69.4	1.8	1.5	2.59	71.6	72.0
Solids, Dissolved		500 mg/l	8	0	287.0	315.0	305.6	310.0	8.9	2.5	2.90	310.0	313.3
Sulfate		250 mg/l	8	0	110.0	127.2	116.7	115.5	5.9	3.5	5.02	119.8	125.4
Vanadium, µg/l (T)			8	2	8.6	14.0	11.1	10.5	2.0	1.2	18.31	12.5	13.8
Zinc (T)		5 mg/l	8	7	0.01	0.01	0.01	0.01	N/A	N/A	N/A	0.01	0.01

1 All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). Blank cells mean there are no relevant criteria for the use listed. ND=Not Detected; N/A=Not Applicable

2 Units as reported in PWCC laboratory analyses. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l)

3 Criteria reflect total (non-filtered) units in published regulations for publically-owned systems. Criteria are Primary MCLs (Maximum Contaminant Levels) except where noted. Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

4 Secondary MCLs (Maximum Contaminant Levels): the maximum (as total or non-filtered) level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq. (Data).

Table WR-7.10. Navajo Aquifer Well (NAV9) Water Quality Summary, 2010 – 2014 [1]

Chemical Constituent [2]	Public Drinking Water MCL [3]	Public Drinking Water MCL [4]	Total Sample Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value	Standard Deviation	Median Absolute Deviation	Percent Relative Standard Deviation	75th Percentile	95th Percentile
Aluminum (T)		0.2 mg/l	10	4	0.0	0.1	0.0	0.0	0.0	0.0	76.63	0.0	0.0
Arsenic, µg/l (T)	10 µg /l		9	0	2.0	3.3	2.9	3.0	0.4	2.5	14.21	3.2	3.3
Bicarbonate			10	0	66.0	98.0	75.0	72.5	8.9	63.1	11.85	75.9	89.5
Boron, µg/l			10	1	20.0	30.0	21.1	20.0	3.3	16.7	15.79	20.0	26.0
Cadmium, µg/l (T)	5 µg /l		9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Calcium			10	0	3.6	3.8	3.7	3.7	0.1	3.6	2.00	3.7	3.8
Chloride		250 mg/l	10	0	2.0	3.0	2.2	2.0	0.4	1.6	19.17	2.0	3.0
Chromium, µg/l (T)	100 µg /l		9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Conductivity			10	0	157.0	177.0	163.1	161.0	6.5	155.5	3.99	165.3	174.3
Copper, µg/l (T)	1,300 µg /l (MCLG)	1,000 µg/l	9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Fluoride	4 mg/l	2 mg/l	10	2	0.2	0.2	0.2	0.2	0.0	0.2	5.40	0.20	0.20
Iron		0.3 mg/l	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Lead, µg/l (T)	15 µg /l		9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Magnesium			10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Manganese		0.05 mg/l	10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Mercury, µg/l (T)	2 µg /l		9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Nitrate as N	10 mg /l		10	0	0.7	0.9	0.8	0.8	0.1	0.7	7.52	0.81	0.85
Nitrite as N	1 mg /l		10	10	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
NO3 + NO2			10	0	0.7	0.9	0.8	0.8	0.1	0.7	7.63	0.81	0.85
pH		6.5 – 8.5	10	0	8.8	9.1	8.9	8.9	0.1	8.8	1.20	9.00	9.10
Selenium, µg/l (T)	50 µg /l		9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND
Sodium			10	0	31.8	34.9	33.2	33.1	1.2	32.1	3.56	34.1	34.9
Solids, Dissolved		500 mg/l	10	0	90.0	130.0	105.4	100.0	12.9	87.1	12.27	113	126
Sulfate		250 mg/l	10	1	1.4	4.8	3.4	3.4	1.0	2.5	29.39	4.10	4.68
Vanadium, µg/l (T)			9	0	9.0	17.0	12.9	13.0	2.7	9.8	20.69	13.00	17.00
Zinc (T)		5 mg/l	9	9	ND	ND	ND	ND	N/A	N/A	N/A	ND	ND

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in micromhos/centimeter (µmhos/cm); pH in Standard Units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). Blank cells mean there are no relevant criteria for the use listed. ND=Not Detected; N/A=Not Applicable

[2] Units as reported in PWCC laboratory analyses. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l)

[3] Criteria reflect total (non-filtered) units in published regulations for publically-owned systems. Criteria are Primary MCLs (Maximum Contaminant Levels) except where noted. Maximum Contaminant Levels are the maximum permissible levels which can be delivered to any user of a public water system. MCLG: Maximum Contaminant Level Goal; reflects the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health or persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

[4] Secondary MCLs (Maximum Contaminant Levels): the maximum (as total or non-filtered) level of a contaminant in a public water system which, in the judgment of the Director, is requisite to protect the public welfare. These may reflect considerations of taste, odor, staining, or others. Action levels for lead and copper are based on the 90th percentile of samples taken, or the highest concentration if less than five (5) samples are taken.

Sources: Navajo Nation EPA 2010, 2008 (Criteria); PWCC 2012 et seq. (Data).

This page intentionally left blank

Appendix WR-8

Cumulative Water Resources Supplemental Information

This page intentionally left blank

WR.8 Cumulative Water Resources Considerations

Historical conditions at NGS and KMC are discussed first in this appendix, from the perspective of resource conditions over time at these main project components. Water resources at NGS and the coal leases are described here over longer timeframes than the recent background 2010 – 2014 period discussed in the main text for existing conditions. From a spatial viewpoint, this appendix section also characterizes regional water resources, within the larger cumulative effects study areas (CESAs). The CESAs are indicated on **Figure 3.7-1** in the main EIS text, and consist of the N-Aquifer footprint west of Chinle Wash, as well as Lake Powell and parts of the Colorado and San Juan rivers.

WR.8.1 NGS Water Resources Over Time

Surface water resources at NGS have not changed from those described earlier for current conditions. The only surface water resource at NGS is an unnamed ephemeral wash.

The initial design and planning memorandum developed with Reclamation in 1973 provided for environmental monitoring as part of NGS development. Except for a short cessation in the early to mid-1990s, SRP has monitored groundwater and seepage at NGS facility since plant operations started in the mid-1970s. Three deep monitoring wells and 58 shallow monitoring wells have been constructed at NGS. Program results are reported to the USEPA. Several of the original shallow wells are now inactive. In 2013, SRP abandoned or replaced 11 wells that penetrated the upper Page/Navajo Sandstone. These activities addressed potential vertical conduit issues from earlier well construction.

In addition to the shallow seepage monitor wells, three recovery wells were installed north of the Unit 1B Cooling Tower to address an underground fuel line leak that occurred in the mid-1990s. Approximately 31,550 gallons of fuel oil were recovered (SRP 2015). In 1996 and 1998, SRP sampled for petroleum hydrocarbons in response to the leak. Sampling results are discussed below.

As mentioned for groundwater resources and in Chapter 2.0, a zone of perched water exists within the Carmel Formation under the plant site. The formation ranges between approximately 10 to 70 feet thick, and has variable permeability depending on rock types and the presence of fractures (SRP 2015). The formation consists of interbedded silty sandstone, siltstone, and claystone. According to geotechnical investigations, fractures occur in one of the Carmel Formation rock types, but are limited in vertical extent (SRP 2015). Some fractures have been cemented off by secondary mineral deposits. Differing water levels and responses to pumping in the perched water removal wells and monitoring wells indicate poor hydraulic connectivity within the Carmel Formation (SRP 2015).

Sources of perched water include evaporation ponds (which have since been lined), leakage from unit cooling tower basins, and unlined drainage ditches. Water levels in the northern part of the plant area around the ponds are dissipating. Water levels in the central plant area are fairly steady. Water levels in the Unit 2 cooling tower area are increasing (SRP 2015). The NGS Perched Water Dewatering Work Plan and the Groundwater Protection Plan will continue to address potential sources.

A joint Navajo Nation EPA/ USEPA site investigation was conducted to assess these conditions in 2001 – 2002. A recovery and monitoring program has been implemented by SRP and coordinated with USEPA to characterize and control the perched water, which is at shallow depths (about 7 to 40 feet) under the plant. SRP is removing and monitoring this water, using six wells to pump water to disposal ponds and recycle it to the plant stream. Recent post-pumping water levels in the recovery wells have remained low, indicating that the program successfully removed a substantial amount of the perched groundwater. The USEPA issued a “No Further Action” letter to SRP in 2003.

Perched water in the Carmel Formation at the plant site is predominantly sodium sulfate type water (SRP 2015). TDS and sulfate concentrations range widely, depending on well location and the probable source of seepage. In general, the lower TDS concentrations (from approximately 1,000 to 8,000 mg/L) are found in well samples from the central power block area. TDS levels in wells near the cooling towers are on the order of 10,000 mg/L. The highest TDS concentrations (approximately 100,000 mg/L) have been observed in samples from wells located near the evaporation ponds in the northern plant area. Sulfate levels in shallow well samples have ranged typically between 1,000 mg/L to 10,000 mg/L. These observed TDS and sulfate levels are characteristic of the plant process water (SRP 2015).

Sampling results for 1996 indicate that metals concentrations at all sampled wells were substantially below limits considered hazardous, as defined by the Resource Conservation and Recovery Act (SRP 2015). These results are consistent with independent consultant sampling and the 2002 USEPA findings (USEPA 2003, as cited in SRP 2015). For the 1996 and 1998 hydrocarbon sampling events, the greatest Total Petroleum Hydrocarbon (TPH) concentration was detected in 1996 at well NA-64, with a level of 37 mg/L. Subsequent TPH concentrations in 1998 ranged from less than 0.1 mg/L to 7.7 mg/L, with 7 of the 8 samples containing less than 1 mg/L. In the 1998 samples, 21 samples (approximately half the total samples) had concentrations of benzene, toluene, and xylenes that measured less than the method detection limit of 0.5 mg/L (SRP 2015).

In addition to monitoring the shallow water zones in the Carmel Formation, SRP monitors the N-Aquifer using much deeper wells, and has tracked moisture conditions in the unsaturated zone above the water table using neutron logging in other wells. Neutron logging below NGS in 1980 indicated that approximately 480 feet of the Page/Navajo Sandstone had available moisture retention capacity, wherein the percent moisture in the formation was less than the specific retention capacity of the formation (SRP 2015). Additional neutron logging in 1997 indicated that no significant moisture content changes had occurred in that zone since the 1980 investigation. A moisture front was noted at the bottom of the Carmel Formation and top of the Page/Navajo sandstones, however.

As mentioned previously, an observation of fracture flow at about the 125-foot depth was made at in the open borehole at deep monitoring well DW-2. This allowed some perched water to migrate to deeper groundwater, creating a temporary spike in TDS and sulfate concentrations in groundwater samples. To remedy this, SRP placed a casing liner in the well to the 660-foot depth in 1989, and subsequent well purging and sampling restored background water quality conditions. Deep well DW-2 has a casing liner to a depth of 700 feet, and additional deep casing at DW-3 is planned to occur sometime in 2015 (SRP 2015).

Fractures are present in the Navajo Sandstone, but data about their occurrence, depth, and connectivity are limited. Some fracture flow occurred at DW-2 as described above, which was quickly mitigated. There is no evidence of a long-term increase in TDS in the groundwater samples from the deep wells, either from plant operations or recharge from Lake Powell.

WR.8.2 Coal Lease Area Water Resources Over Time

Numerous water resources occur in the former Black Mesa Mine area and just beyond the coal lease area boundary. Closer in to the KMC, **Figure 3.7-3** in the main EIS text depicts the major streams that drain through the coal lease areas and beyond the lease boundaries. A number of springs occur near the KMC but outside the lease boundaries, and many springs occur elsewhere on Black Mesa and in the cumulative study area. In addition, within the coal lease area boundary but outside the KMC, a number of sediment ponds and impoundments exist at the former Black Mesa Mine area.

Streams

As described in Chapter 2.0, stream diversions were constructed to maintain surface hydrologic conditions while facilitating removal of the coal resource. Under SMCRA permit AZ-0001, PWCC constructed five diversions in the early 1980s. An additional diversion was constructed in 1993. The original five are all on ephemeral stream reaches. The sixth was designed and built to be a permanent feature on Reed Valley Wash; it is classified as an intermittent stream section. All of these structures have been designed, built, and maintained according to standard hydrologic and hydraulic engineering practices, and approved through applicable regulatory programs. Elsewhere within the lease areas, washes such as Moenkopi Wash, Dinnebito Wash, Yellow Water Canyon, Yucca Flat Wash, and others are avoided by mining disturbance.

As previously discussed, runoff and sediment yield in the mine areas are managed by agency-approved temporary and permanent ponds or impoundments. While providing water for habitat and grazing, these may reduce streamflows during storm events, snowmelt, or the southwestern monsoon season. Based on previous assessment work, OSMRE determined that the watershed area for the downstream PWCC surface gage (Site 155) was 253 square miles, and that generally between 20 to 25 percent of that area (up to approximately 63 square miles) of higher-elevation headwaters have been controlled by surface impoundments since 1985 (OSMRE 2011b). This represents approximately 4 percent of the 1,629 square miles of the Moenkopi Wash drainage area at Moenkopi (USGS Gage 09401260). Up to about 30 percent of the Site 155 basin area on Moenkopi Wash would be controlled by PWCC impoundments in the future. Similarly, for Dinnebito Wash, ten percent or less of the total basin area at downstream PWCC Site CG34 (51.7 square miles) has been controlled by surface impoundments historically. Up to 15 percent of the total basin area, or about 7.8 square miles, would be controlled by PWCC impoundments in the future (OSMRE 2011b). This represents approximately 1.6 percent of the watershed area at USGS Gage 09401110 on Dinnebito Wash at Sand Springs, about three-quarters of the way between the coal leases and the confluence with the Little Colorado River.

Stream water quality has been monitored at numerous locations in the coal lease areas since the early 1980s, and some monitoring occurred prior to that. For Moenkopi Wash and Dinnebito Wash, upstream and downstream water quality sample results were paired for further examination for this EIS. Statistical results for these cumulative water quality reviews are summarized and compared to surface water quality standards in **Appendix WR-1**, **Tables WR-1.16** through **WR-1.19**.

In paired samples dating from 1981 until 2008, PWCC upstream locations 16, 35, and 50 in the Moenkopi Wash watershed had an average TDS concentration of 655 mg/L, and a median concentration of 390 mg/L. Sulfate concentrations averaged 344 mg/L, with a median of 150 mg/L. Downstream samples at Sites 26, 25, and 155 in the Moenkopi Wash watershed for the same period had an average TDS concentration of 1,338 mg/L and a median concentration of 690 mg/L. Sulfate concentrations had an average value of 760 mg/L and a median value of 383 mg/L. These are similar concentrations to the approximately 30 USGS sampling results on Moenkopi Wash at Moenkopi (USGS 09401260) from the late 1970s and early 1980s.

For Dinnebito Wash, upstream samples from 1985 until 2005 at PWCC Site 78 had an average TDS concentration of 1,502 mg/L and a median value of 1,239 mg/L. Sulfate concentrations had an average value of 957 mg/L and a median value of 786 mg/L. Paired downstream samples at PWCC location CG34 for the same period had an average TDS concentration of 1,140 mg/L and a median value of 927 mg/L. Downstream sulfate concentrations had an average value of 713 mg/L and a median value of about 590 mg/L. These are greater concentrations than the four samples comprising USGS data for Dinnebito Wash at Sand Springs in the mid-1990s. The distributions of baseflow versus runoff sampling events are not known for historical sampling by PWCC or the USGS on either Dinnebito or Moenkopi Wash, and concentrations differ between these flow conditions.

Ponds

As of 2019, there will be approximately 50 permanent impoundments within the leasehold, and about 115 temporary impoundments. Approximately eight temporary impoundments would be removed by 2019, and approximately 101 pond or impoundment structures will have been reclaimed. The other structures remain for controlling runoff and sediment along existing roads, facilities in place (see Chapter 2.0), and reclaimed lands still under regulatory jurisdiction or lease agreements. PWCC actively manages the ponds and impoundments at the former Black Mesa Mine area, similar to the program at KMC. Pond discharges are managed by pumping, and timed according to retained volumes, the available storage at nearby ponds, water quality, runoff and streamflow occurrence, and permit conditions. Evaporative conditions exist at all of the retention ponds, both at KMC and the former Black Mesa Mine area. Water quality in the ponds is similar to that described for recent conditions at KMC and summarized in **Appendix WR-2**.

Over the projected Life-of-Mine duration, there would be approximately 51 permanent impoundments and about 142 temporary impoundments. Including the eight impoundments removed before 2019, approximately 241 ponds and impoundments will be reclaimed.

Alluvium

Alluvial wells also have been sampled within the coal lease areas since the 1980s. Upstream and downstream samples can be distinguished for alluvial wells on Moenkopi Wash and tributaries, and on Dinnebito Wash as well. **Appendix WR-4, Tables WR-4.9** through **WR-4.12** summarize water quality for these samples over time, at upstream and downstream locations. For 86 upstream alluvial well samples representing the Moenkopi Wash drainage, the average TDS concentration was 3,364 mg/L, and the median value was 3,125 mg/L. Sulfate concentrations averaged 1,995 mg/L, with a median of 1,885 mg/L. These samples are from wells in alluvial deposits upstream of mining activities, and represent background concentrations. Arsenic was not detected in 83 of 86 samples (96 percent), and had both average and median values of 1 µg/L in the remaining three samples. Mercury was not detected in 85 of 86 samples. Selenium was detected in 54 samples (63 percent), with an average concentration of 2.9 µg/L and a median value of 2.0 µg/L.

In downstream samples for the Moenkopi Wash drainage, the average TDS concentration was 3,988 mg/L, and the median value was 4,154 mg/L. Sulfate concentrations averaged 2,381 mg/L, with a median value of 2,586 mg/L. Arsenic was not detected in 95 out of 114 analyses (83 percent), and had average and median concentrations of 1.6 and 1.0 µg/L, respectively, in the remaining 19 samples. Mercury was not detected in 108 out of 114 analyses (95 percent), and averaged 0.55 µg/L in the remaining 6 samples, with a median value of 0.39 µg/L. Selenium was not detected in 36 of 114 samples (32 percent), and had an average value of 11.6 µg/L and a median concentration of 10.4 µg/L in the remaining 78 samples.

Historical sampling upstream on Dinnebito Wash indicates an average TDS concentration of 4,384 mg/L in the alluvium, with a median value of 4,350 mg/L. Sulfate concentrations averaged 2,768 mg/L, with a median value of 2,800 mg/L. Again, these samples represent background concentrations in alluvium upstream of mining activities. Arsenic was not detected in 11 out of 31 samples (35 percent), and had an average concentration of 4.2 µg/L in the remaining 20 samples. The median detected arsenic concentration was 2.0 µg/L. Mercury and selenium were not detected in all but one sample.

Downstream on Dinnebito Wash, alluvial well samples had an average TDS concentration of 6,600 mg/L, with a median value of 6,409 mg/L. Sulfate concentrations averaged 3,996 mg/L, with a median of 3,900 mg/L. Arsenic was not detected in 18 of 20 samples (90 percent), and was 2.0 µg/L in both the remaining samples. Mercury was not detected in 62 of 64 samples, and had both average and median concentrations of 0.25 µg/L in the remaining two samples. Selenium was not detected in 32 of 64 samples (50 percent), and averaged 4.75 µg/L in the remaining 32 samples, with a median value of 3.5 µg/L.

For comparisons, trace element concentrations from alluvial wells were checked against surface water livestock watering standards. Although groundwater analyses using dissolved concentrations do not directly compare to total concentrations used as surface water criteria, a conclusion can be made. Trace elements in the alluvial samples are typically far below the concentrations comprising livestock watering criteria in stream (surface) water standards.

For example, in downstream alluvial samples representing the Moenkopi Wash drainage, one value for lead was detected in 112 analyses. That sample had a dissolved concentration of 100 µg/L. The livestock watering criterion is 100 µg/L, as a total concentration. In the same sample set, one value (57 µg/L) for dissolved selenium out of 115 analyses exceeded the livestock watering criterion (50 µg/L as a total concentration). Maximum dissolved values for other trace elements were far below livestock watering criteria. In upstream Moenkopi Wash alluvium, lead was detected twice in 86 samples, once with a dissolved concentration of 200 µg/L, and once with 80 µg/L. Thus, the average concentration is 140 µg/L, above the livestock watering criterion of 100 µg/L as a total concentration, but dissolved lead was not detected in 84 of the 86 samples. As a source of livestock water, alluvial groundwater does not exceed the surface water trace element criteria used as comparative benchmarks.

Springs

Approximately 30 spring locations have been mapped on the Wepo Formation footprint within the coal lease areas, and approximately another 15 spring sites are known to occur near the leases (within 1 mile) but outside the lease boundaries. While most are not monitored by PWCC or a tribal organization, it is assumed that these nearby Wepo aquifer springs have a range of flows and water quality similar to those monitored within the lease areas and described in **Appendix WR-3**.

Background conditions in springs near the coal lease areas can be ascertained from PWCC sampling at monitoring sites NSPG111, Goat#2, and Hogan Gulch. In particular, spring monitoring sites NSPG111 amd Hogan Gulch are upgradient of mining activities, and separated from them by substantial washes and side canyons (see **Figure WR-3.1**). Spring monitoring site NSPG147 may also provide data separated from mining activity in the southwestern part of the lease areas. Sampling in 2010 through 2012 at NSPG111 indicates a range of TDS concentrations from 6,150 to 6,480 mg/L. Sulfate concentrations ranged from 3,800 to 4,000 mg/L. Historical sampling since 1980 at NSPG111 indicates an average TDS value of 6,662 mg/L, and a median of 6,480 mg/L. Sulfate concentrations averaged 4,438 mg/L, with a median value of 4,330 mg/L. At the Hogan Gulch spring, several samples from the late 1990s indicate an average TDS concentration of 6,577 mg/L, with a median value of 7,250 mg/L. Sulfate values were 4,297 and 4,820 mg/L for the average and median concentrations there, respectively. Samples at NSPG147 had an average TDS concentration of 9,192 mg/L, and a median value of 9,070 mg/L. Sulfate concentrations there had an average value of 5,893 mg/L, with a median of 5,850 mg/L. These conditions indicate that natural TDS and sulfate values can be high in the locale.

In the Permit Application Package, Attachment 17 in Volume 15 summarizes earlier historical spring water quality monitored by PWCC. In samples from 1980 through 1985, background spring site NSPG111 had an average TDS value of 7,168 mg/L, with a range of 5,600 to 8,976 mg/L. Background sulfate concentrations there averaged 4,513 mg/L, and ranged from 3,250 to 5,851 mg/L (**Table WR-8.1**). These were generally the highest concentrations of the five springs summarized. Early data presented for other springs sampled historically are summarized below. These are all mixed sulfate or magnesium sulfate water types.

Table WR-8.1 Summary of 1980 - 1985 Historical Spring Water Quality

Spring Site Number	Average TDS mg/L	TDS Range mg/L	Average Sulfate, mg/L	Sulfate Range, mg/L
0091	2,082	1,087 – 4,137	1,127	558 – 2,250
0092	3,207	1,558 – 3,643	1,688	788 – 3,050
0097	6,846	6,652 – 7,020	4,077	3,884 - 4,375
0111	7,168	5,600 – 8,976	4,513	3,250 – 5,851
0140	4,263	3,139 – 6,100	2,818	1,710 – 3,710

Source: PWCC Permit Application Package, Volume 15, Attachment 17.

Additional information for spring water quality at PWCC sites is presented in **Appendix WR-3**.

Wepo Formation Wells

Of the eight Wepo Formation wells selected to represent background conditions in the previous OSMRE Cumulative Hydrologic Impact Assessment, four have been idled with respect to continuous water level monitoring (OSMRE 2011b; PWCC 2014). The idled wells include Wepo wells 47, 55, 57, and 61. Recent water levels in the remaining four background wells (Wepo wells 56, 59, 65, and 67) are summarized in **Appendix WR-5**. The latter two have background data collected during the period 1980 through 1984 (**Appendix WR-5**). Over time, water levels in Wepo 65 have remained near the deeper levels recorded during the background period, generally near 145 feet bgs. Water levels in Wepo 67 have remained generally in the 180- to 185-foot depth, in about the lower 67 to 75 percent of background conditions that ranged between 129.5 to 204.5 feet bgs (**Appendix WR-5**).

Of Wepo Formation monitoring wells that are likely affected by mining, Wepo Wells 49, 54, and 66 have background water levels from the period 1980 – 1984. Water levels in Wepo 49 have been within their background range, and are frequently shallower (higher). Water levels in Wepo 54 have remained within the central part of their background range, and levels in Wepo 66 have basically duplicated their background range.

With respect to water quality, a substantial number of samples have been collected and analyzed for the Wepo Formation within the coal lease areas. These cumulative data are summarized in **Appendix WR-5, Tables WR-5.8** through **WR-5.12**. In samples representing background Wepo Formation conditions, dissolved lead concentrations exceeded the livestock watering surface water criterion (100 µg/L as total lead) in 3 out of the 30 samples (10 percent) in which lead was detected. Dissolved lead was not detected in 132 out of 158 samples (83 percent). The TDS livestock advisory level (2,000 mg/L) was exceeded 5 times out of 160 samples (3 percent). Four background TDS “exceedances” were at Wepo 65, and the remaining “exceedance” was at Wepo 59. Fluoride exceeded the livestock criterion (2 mg/) in 52 out 162 samples (32 percent), most commonly at Wepo Wells 55, 65, 67, and 69. Greatest concentrations were at Wepo wells 55 and 67. The nitrate plus nitrite criterion (0.132 mg/L) was exceeded in 9 out of 54 samples (17 percent), mainly at Wepo 67. Sulfate in background Wepo wells exceeded the livestock advisory level (1,000 mg/L) in 13 of 156 samples (8 percent), mainly at Wepo 59. All other constituents were within livestock watering standards, although trace elements were analyzed for dissolved concentrations.

In other Wepo wells in the northwestern part of the coal lease areas, fluoride exceeded the livestock surface water criterion in 36 of 110 samples (33 percent), primarily at Wepo 41, but also in well 42 and others. The lead criterion was exceeded by dissolved concentrations in six of 109 samples (5.5 percent). Dissolved lead was not detected in 86 samples (78 percent). Nitrate plus nitrite concentrations exceeded the livestock watering criterion in 7 of the 38 samples (18 percent) in which they were analyzed. The TDS advisory level was exceeded in 31 out of 110 samples (28 percent), most consistently at Wepo 41. The sulfate advisory level for livestock was exceeded in 29 out of 110 samples (26 percent), primarily at Wepo 41. All other constituents were within livestock watering standards, although trace elements were analyzed for dissolved concentrations.

In other Wepo wells in the northeastern part of the coal lease areas, fluoride exceeded the livestock surface water criterion in 10 of 60 samples (17 percent), all at Wepo 62R. The lead criterion was exceeded by dissolved concentrations in 3 of 60 samples (5 percent). Dissolved lead was not detected in 49 samples (82 percent). Nitrate plus nitrite concentrations did not exceed the livestock watering criterion in the 26 samples in which they were analyzed. The TDS advisory level was exceeded in 7 out of 60 samples (12 percent), most consistently at Wepo 62R. The sulfate advisory level for livestock was barely exceeded in one out of 59 samples (1.7 percent). All other constituents were within livestock watering standards, although trace elements were analyzed for dissolved concentrations.

In other Wepo wells in the southeastern part of the coal lease areas, fluoride exceeded the livestock surface water criterion in 6 of 32 samples (19 percent), primarily at Wepo 68. The lead criterion was exceeded by dissolved concentrations in 5 of 32 samples (16 percent). Dissolved lead was not detected in 24 samples (75 percent). Dissolved selenium did not exceed the livestock watering criterion (50 µg/L as total selenium), but matched it in one sample out of 32 (3 percent) in which it was analyzed. Dissolved selenium was not detected in 29 samples. Nitrate plus nitrite concentrations exceeded the livestock watering criterion in 2 of the 13 samples (15 percent) in which they were analyzed. The TDS advisory level was exceeded in 26 out of 32 samples (81 percent), almost all at Wepo 66. The sulfate advisory level for livestock was exceeded in 14 out of 31 samples (45 percent), all at Wepo 66 after June 1986. All other constituents were within livestock watering standards, although trace elements were analyzed for dissolved concentrations.

In other Wepo wells in the former Black Mesa Mine area, fluoride exceeded the livestock surface water criterion in 86 of 191 samples (45 percent), most consistently at Wepo wells 40, 44, and 45. The lead criterion was exceeded by dissolved concentrations in 6 of 182 samples (3.3 percent). Dissolved lead was not detected in 152 samples (84 percent). Dissolved selenium exceeded the livestock watering criterion (50 µg/L as total selenium) in 5 out of 191 samples (2.6 percent), all at Wepo 46. Dissolved selenium was not detected in 178 samples. Nitrate plus nitrite concentrations exceeded the livestock watering criterion in 9 of the 66 samples (14 percent) in which they were analyzed. The TDS advisory level was exceeded in 61 out of 190 samples (32 percent) at various wells. The sulfate advisory level for livestock was exceeded in 46 out of 188 samples (24 percent), primarily at Wepo wells 46 and 53. All other constituents were within livestock watering standards, although trace elements were analyzed for dissolved concentrations.

N-Aquifer Wells and Water Quality

Historic water levels and changes in N-Aquifer (NAV) wells within the PWCC leasehold are summarized in **Table WR-8.2** below. Recoveries are occurring as a result of lower annual pumping rates since the coal slurry pipeline stopped operating at the end of 2005.

Table WR-8.2 Historic N-Aquifer Water Levels, PWCC Leasehold

Well	Original Static Water Level, feet bgs	Maximum Static Water Level, feet bgs	Artesian Head Declines, feet	Year of Maximum Static Level	Year 2013 Static Water Level, feet bgs	Total 2013 Water Level Recovery, feet [1]
2	740	1,170	430	1986	---	---
3	730	1,155	425	2005	985.4	169.6
4	490	1,050	560	1990	729.6	320.4
5	830	1,384	554	2001	1,124.4	259.6
6P	895	1,344	449	2004	1,180.9	163.1
7	700	1,140	440	1991	875.5	264.5
8	1,050	1,270	220	1992	1,074.0	196.0
9	906	985	79	2003	882.2	102.8

[1] From maximum static water level. Blanks indicate no data.

Source: PWCC 2014.

In December 2014, PWCC received approval from OSMRE to abandon and reclaim NAV5 in accordance with procedures established for well abandonment provided in the Arizona Department of Water Resources “Well Abandonment Handbook” published in September 2008. PWCC also has idled N-Aquifer wells NAV3 and NAV9. NAV3 is in the Navajo-Hopi Joint Use Area, and NAV9 is located on

Hopi Tribe surface lands. These activities are ongoing as proposed minor permit revision applications to OSMRE Permit AZ0001E.

Recent (2010 – 2014) water quality summaries for the N-Aquifer are presented in **Appendix WR-7**. In the Permit Application Package, Attachment 23 in Volume 15 summarizes earlier historical N-Aquifer water quality monitored by PWCC. These results are summarized below in **Table WR-8.3**.

Table WR-8.3 Summary of 1980 - 1985 Historical Navajo Well Water Quality

NAV Well Number	Historical Well Number	TDS Average (Minimum / Maximum), mg/L	Sulfate Average (Minimum / Maximum), mg/L	Fluoride Average (Minimum / Maximum), mg/L	Lead Average (Minimum / Maximum), μg/L [1]	Selenium Average (Minimum / Maximum), μg/L [1]
NAV2	0020	148 (78 / 253)	14.7 (1.0 / 29)	0.16 (0.10 / 0.40)	29.3 (20 / 50)	13.2 (5.0 / 50)
NAV3	0028	152 (69 / 290)	11.9 (1.0 / 29)	0.33 (0.10 / 0.50)	30.0 (20 / 50)	13.0 (5.0 / 50)
NAV4	0024	157 (77 / 266)	13.8 (4.0 / 28)	0.17 (0.10 / 0.30)	29.4 (20 / 50)	13.2 (5.0 / 50)
NAV5	0022	175 (102 / 238)	15.8 (1.0 / 40)	0.19 (0.10 / 0.40)	30.0 (20 / 50)	12.8 (5.0 / 50)
NAV6	0021	169 (59 / 272)	13.2 (1.0 / 26)	0.20 (0.10 / 0.30)	30.0 (20 / 50)	12.8 (5.0 / 50)
NAV7	0030	166 (113 / 259)	13.6 (1.0 / 24)	0.18 (0.10 / 0.24)	31.3 (20 / 50)	12.8 (5.0 / 50)
NAV8	0115	404 (268 / 560)	152 (100 / 210)	0.19 (0.10 / 0.30)	28.5 (20 / 50)	10.4 (5.0 / 20)
NAV9	0156	141 (98 / 250)	3.5 (1.0 / 8.0)	0.17 (0.10 / 0.20)	20.0 (20 / 20)	10.0 (10 / 10)

[1] Dissolved.

Source: PWCC 2012 et seq.

WR.8.3 Regional Streams and Washes

Most of the major washes in the cumulative study area drain south and west to the Little Colorado River. This is particularly true of drainages originating on Black Mesa, such as Moenkopi Wash, Dinnebito Wash, Oraibi Wash, Polacca Wash and Wepo Wash, and Jeddito Wash. In contrast, Chinle Wash/Chinle Creek, Laguna Creek, and Navajo Canyon are major streams that drain to the San Juan River or its Lake Powell arm. Most of these channels have been monitored for flow and water quality by the USGS, at sites far removed from the coal lease areas. Monthly average flows for these downstream locations on major streams are indicated below (**Table WR-8.4**). All these locations are distant from the coal lease areas, and except for the Chinle Creek and San Juan River gages, are located well toward the southern and western Hopi Reservation boundaries as depicted in the main EIS text on **Figure 3.7-3**. The Chinle Creek and San Juan River gages are located near the Utah state line to the northeast.

Table WR-8.4 Monthly Mean Flows, Major Waterbodies in the Cumulative Study Area [1]

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Moenkopi Wash at Moenkopi (USGS 09401260)	4.7	6.4	3.4	2.3	2.3	0.42	15	33	28	13	5.1	3.2
Dinnebito Wash near Sand Springs (USGS 09401110)	1.4	2.9	0.95	0.35	0.36	0.26	7.6	17	12	4.6	0.79	0.98
Oraibi Wash near Tolani Lake (USGS 09400562)	2.8	2.6	0.58	0.05	0.03	0.03	2.3	14	9.0	6.1	0.08	0.55
Polacca Wash near Second Mesa (USGS 09400568)	2.1	3.0	0.28	0.20	0.30	0.06	6.2	21	7.7	6.3	0.32	0.33
Jeddito Wash near Jeddito (USGS 09400583)	0.00	0.00	0.00	0.00	0.00	0.03	0.47	1.7	2.1	0.45	0.09	0.00
Chinle Creek Near Mexican Water (USGS 09379200)	15	24	20	47	39	4.0	22	50	39	22	12	7.4
San Juan River near Bluff, UT (USGS 09379500)	1,080	1,360	1,770	3,130	4,900	5,230	2,300	1,680	1,600	1,480	1,180	1,060

[1] Flows are in cubic feet per second (cfs). Periods of record: Moenkopi Wash 1976-2014; Dinnebito Wash 1993-2014; Oraibi Wash 1995-2013; Polacca Wash 1994-2014; Jeddito Wash 1993-2005; Chinle Creek 1964-2014; San Juan River 1914-2014.

Source: USGS-NWIS 2016.

The table values above imply that most of these streams are perennial at the USGS gaging locations except Jeddito Wash, which is likely ephemeral. Of course, during dry years there are periods of no flow along every stream. On Moenkopi Wash, low or no flows are common in June. The long-term monthly averages for winter and spring months on Oraibi Wash actually reflect only a few atypical wet months among a majority of no-flow values in other years. Numerous no-flow monthly averages occur along Oraibi Wash from December through June and into July. Based on data at the USGS gage location, the stream is actually ephemeral there. Both Polacca and Chinle washes consistently flow throughout the year at the USGS gage locations, but both have markedly low flows in June.

More detailed flow duration analyses were conducted on washes occurring within the Hopi Reservation (ADWR 2008). Recent available data indicate that perennial reaches occur along Dinnebito and Polacca washes, intermittent sections occur along Moenkopi Wash, and ephemeral flows occur in Oraibi Wash and Jeddito Wash (ADWR 2008). In that study, ephemeral conditions were defined as streamflows that were measurable in less than 10 percent of the days of the year. Intermittent sections had measurable streamflows during 10 percent or more days of the year, but less than 100 percent. Perennial reaches flowed all the time, or during 100 percent of the days. ADWR noted that in a 1916 investigation, Moenkopi Wash was perennial from near its confluence with the Little Colorado River to a point about five miles upstream of the Coconino/Navajo county line, at its confluence with White Ruin Canyon. Subsequent investigations indicate that during the 1950s and 1960s (prior to mine-related pumping), Moenkopi Wash was perennial over a much shorter distance, from the Moenkopi/Tuba City locale upstream about 10 or 12 miles to Coal Mine Canyon (Cooley et al. 1969). Cooley et al. (1969) also indicated perennial segments along Dinnebito, Polacca, and Jeddito washes. These reaches remain along Dinnebito, and Polacca washes, but Jeddito Wash is currently thought to be ephemeral along its length (ADWR 2008).

Regional flow studies by the ADWR indicate that during the period 1981 through 2006, an average of 6,820 acre-feet per year of streamflow flowed onto the Hopi Reservation through the major washes. An average of 13,900 acre-feet per year flowed out. Thus, an average of about 7,080 acre-feet per year was generated on Hopi Tribal lands (ADWR 2008). Median values indicated approximately 10,800 acre-feet per year of inflows over the period, with about 16,900 acre-feet per year of outflows. A median value of 6,100 acre-feet per year was estimated to be derived from Hopi Tribal lands. For major washes, **Table WR-8.5** indicates estimated upstream inflows and downstream outflows as the channels cross Hopi Tribal lands.

Table WR-8.5 Estimated Inflows and Outflows, Major Washes across Hopi Tribal Lands

Stream Channel	Location Description	Average Flow (acre-feet/year)	Median Flow (acre-feet/year)
Moenkopi Wash, upstream inflow	Near southwest corner of coal leasehold	350	514
Moenkopi Wash, downstream outflow	At downstream edge, community of Moenkopi	4,620	4,140
Dinnebito Wash, upstream inflow	Northeast edge of reservation, about 15 miles south of Coal Mine/Moenkopi confluence.	191	560
Dinnebito Wash. downstream outflow	Southwest edge of reservation, about 17 miles upstream from Little Colorado River	1,780	2,460
Oraibi Wash, upstream inflow	North-central corner of reservation boundary	400	494
Oraibi Wash, downstream outflow	Southern reservation boundary	1,610	1,560
Wepo Wash, upstream inflow	Northeastern reservation boundary	108	142
Polacca Wash, upstream inflow	Northeastern reservation boundary	156	152
Polacca Wash, downstream outflow	Southern reservation boundary	1,250	1,520
Jeddito Wash, upstream inflow	Northeastern reservation boundary	72	221
Jeddito Wash, downstream outflow	Southern reservation boundary	191	208

Source: ADWR 2008.

Additional USGS flow data are available along Laguna Creek near Kayenta, where the agency conducted an extensive system-wide investigation on one day, November 16, 1994. The following table summarizes flow and other data from that investigation, at ten sampling sites along about 45 linear miles where Laguna Creek flows past the locations listed. While there are no rainfall records at Kayenta for this period, precipitation at Betatakin in November 1994 was about 34 percent above the long-term average for the month, and closer to the averages for July, August, or September. Based on this, the flows indicated below are probably somewhat greater and more extensive than normal for November. As can be seen in the **Table WR-8.6** below, flows are fairly small and vary from one location to another on the same day, due to seepage losses into the sandy channel, bedrock outcrops that force that sub-surface flow back into the stream, and inflows from tributaries and springs.

Table WR-8.6 Laguna Creek Systematic Sampling, November 1994

Measured	At Tsegi	Below Parrish Creek	At Kayenta	Near Lion Rock	Near Church Rock	Near Baby Rocks	Near Red Point	Above Denne-hotso	Below Denne-hotso	Above Chinle Wash
Flow	5.65	0.71	4.51	2.16	2.08	3.25	5.88	3.32	1.12	1.47
pH	7.9	8.0	7.9	7.9	7.9	7.8	7.8	7.7	7.7	7.8
TDS	180	222	252	400	307	293	322	320	325	335
SpCond	319	381	422	645	512	483	529	533	546	561

[1] Data are presented in the table from upstream (left side) to downstream (right side). Flow data are in cubic feet per second. TDS: total dissolved solids, milligrams per liter; pH: standard units; SpCond: Specific Conductance in microsiemens per centimeter.

Source: USGS-NWIS 2016.

Water quality data in **Table WR-8.6** above indicate generally increasing salt contents along Laguna Creek with distance between Tsegi and "near Lion Rock" (about 3 miles downstream of Kayenta). In these upper reaches of the channel, steep shale and sandstone rock outcrops and saline stream terraces are common. A mixture of geologic units, including the Morrison and Chinle formations, outcrop in or near the upper part of the watershed. At and downstream of Church Rock, the Carmel Formation and sandstones of the Navajo and Kayenta formations are dominant along the drainage and the Chinle and Morrison formations are more distant (Cooley et al. 1969). By Church Rock (about 7 miles east of Kayenta) and then downstream, the extensive influence of the Navajo Sandstone has moderated water quality to more consistent characteristics.

The USGS and tribal organizations have also sampled water quality along the major washes listed in **Table WR-8.4**. In USGS data available from approximately 30 samples on Moenkopi Wash at Moenkopi (USGS 09401260) in the late 1970s and early 1980s, water was dominantly a mixed sulfate type, with sulfate concentrations ranging from 220 to 2,300 mg/L, with average and median values of 642 mg/L and 315 mg/L, respectively. Total dissolved solids concentrations ranged from 470 to 3,790 mg/L, with average and median values of 1,147 and 680 mg/L, respectively. Boron concentrations ranged from less than 20 to 190 µg/L. Samples appear to represent a mix of baseflows and runoff. Trace elements were analyzed by USGS for a sample in late October, 2011. These data are presented in **Table WR-8.7**.

Two USGS samples from Oraibi Wash in early August 1997 reflect a calcium sulfate water type. Sulfate contents were 493 and 756 mg/L, and total dissolved solids were 935 and 1,340 mg/L. Dissolved arsenic concentrations were 1 microgram per liter. Dissolved boron concentrations were 89 and 109 µg/L. There were no later trace element analyses.

In four samples from the mid-1990s, Dinnebito Wash near Sand Springs (USGS 09401110) had mixed to sodium sulfate water types. Samples appear to mainly represent runoff, and sampled constituent concentrations are generally lower than data for other washes. This could be due to a different sampling date (October 7, 2011 versus October 27, 2011, for Moenkopi and Polacca washes). Sulfate concentrations ranged from 238 to 470 mg/L, with average and median values of 364 mg/L and 375 mg/L, respectively. Total dissolved solids concentrations ranged from 475 to 849 mg/L, with average and median values of 698 and 734 mg/L, respectively. Boron concentrations ranged from 91 to 200 µg/L. Trace elements were analyzed by USGS for a sample in early October, 2011. These data are presented in **Table WR-8.7**.

In nine samples from the 1990s, Polacca Wash at Second Mesa (USGS 09400568) had mixed sulfate to sodium sulfate water types. Samples appear to represent a mix of baseflows and runoff. Sulfate concentrations ranged from 120 to 1,600 mg/L, with average and median values of 806 mg/L and 635 mg/L, respectively. Total dissolved solids concentrations ranged from 314 to 1,160 mg/L, with average and median values of 948 and 1,120 mg/L, respectively. Boron concentrations ranged from 50 to 440 µg/L. Trace elements were analyzed by USGS for a sample in late October, 2011. These data are presented in **Table WR-8.7**.

Water quality was summarized for major washes crossing the Hopi Reservation (ADWR 2008). One or more secondary drinking water standards were exceeded at 24 sites along Moenkopi Wash, Dinnebito Wash, and other channels. For the same 24 sites, livestock water quality standards were exceeded at seven locations, and irrigation and primary drinking water standards were each exceeded at two sites (ADWR 2008). Sulfate, pH and electrical conductivity (as a surrogate for TDS) were the most common water quality exceedances. Geologic strata were identified as the likely source of water quality exceedances (ADWR 2008).

Sediment yields also have been studied on several major regional washes by the Hopi Tribe (ADWR 2008). Most of the major channels have sediment loads exceeding 20 acre-feet per year. Some are estimated to transport over 50 acre-feet per year. Upper Moenkopi Wash within the coal leasehold was estimated to yield about 17 acre-feet per year (ADWR 2008). At the confluence with Begashibito Wash, Moenkopi Wash was estimated to yield about 58 acre-feet per year. Upper Jeddito Wash had lower sediment yields overall, about 3 or 4 acre-feet per year. Polacca Wash and Oraibi Wash had fairly steady sediment yields across the central parts of their watersheds, at about 70 to 80 acre-feet per year (ADWR 2008). Estimates on Moenkopi, Dinnebito, Polacca and Jeddito washes indicate that their sediment loads increased substantially in a downstream direction, to several hundred acre-feet per year.

A number of impoundments have been built along washes within the cumulative study area. Within Hopi Tribal lands, approximately 440 impoundments have been identified with intact embankments, with a combined estimated storage volume of about 2,553 acre-feet (ADWR 2008). These include small stock ponds as well as larger impoundments such as Pasture Canyon Reservoir and Keams Lake. If the spatial density of impoundments is similar elsewhere within the entire cumulative study area, then roughly 1,800 impoundments would occur in the CESA, with a combined storage of roughly 11,000 acre-feet. It is likely that these projections are high, since much of the CESA has flatter, drier topography that would be less suited to impoundments.

Other surface water features on the major washes in the cumulative study area include dikes built on Begashibito and middle Oraibi Wash, and Pasture Canyon. These store water and moisture for livestock, and help control runoff and erosion. Pasture Canyon Reservoir near Tuba City, and the wetlands along Begashibito Wash northeast of Highway 160 near Tonalea, are other surface water features. Irrigated farmlands are extensive along lower Moenkopi Wash.

Table WR-8.7 Trace Element Concentrations for Recent USGS Samples on Major Washes [1]

Location	Date	Aluminum	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Molybdenum	Selenium	Vanadium	Zinc
Moenkopi Wash at Moenkopi (USGS 09401260)	October 2011	270	53	No data	13	185	736	261	970	1.31	7.6	4.64	801	1,390
Dinnebito Wash near Sand Springs (USGS 09401110)	October 2011	1.0	22.6	No data	9.92	75.3	440	936	557	1.01	31.4	2.92	252	778
Polacca Wash near Second Mesa (USGS 09400568)	October 2011	191	32.7	No data	10.4	133	569	168	872	0.442	18.3	4.61	517	1,230

[1] All values represent total concentrations in µg/L, except aluminum and iron in milligrams per liter.

Source: USGS-NWIS 2016.

WR.8.4 The San Juan River

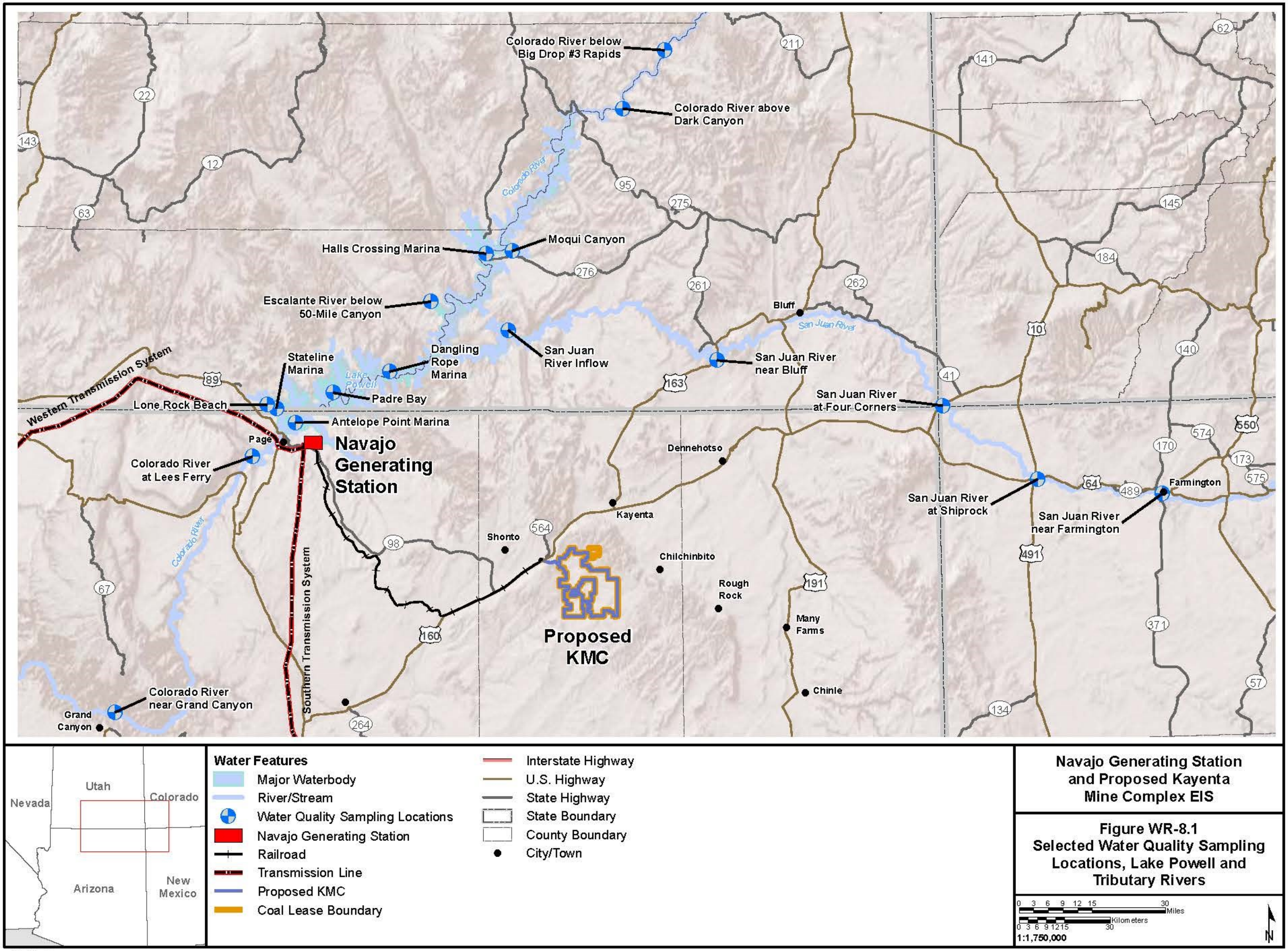
Downstream of Navajo Dam in New Mexico, the San Juan River flows past irrigated lands near Farmington, then past the town of Shiprock, and into Utah before entering Lake Powell (see main text **Figure 3.7-1**). The Four Corners and San Juan coal-fired power plants are located along the New Mexico section of the river between Farmington and Shiprock. Airborne depositions of trace elements and their effects on water quality and aquatic ecosystems are part of cumulative impact considerations for the NGS-KMC EIS. Recent existing surface water quality at several USGS monitoring locations are presented in **Table WR.8-8**. A general increase in common analytes (calcium, chloride, specific conductance, magnesium, sodium, sulfate, and total dissolved solids) can be seen from upstream at Farmington to downstream at Bluff. Dissolved arsenic values increase similarly. Locations of these sampling sites are depicted in **Figure WR.8-1**.

Table WR.8-8 San Juan River Water Quality downstream of Navajo Dam, New Mexico, 2000 – 2016 [1.]

Water Quality Constituent	San Juan River at Farmington, NM (USGS 09365000)	San Juan River at Shiprock, NM (USGS 09368000	San Juan River at Four Corners, NM (USGS 09371010)	San Juan River at Bluff, UT (USGS 09379500)
Arsenic µg/l (T)	5.3	7.9	9.80	9.2
Arsenic µg/l (D)	0.6	0.81	1.08	1.6
Bicarbonate	126.4	138.4	138.2	143.9
Calcium	53.1	58.5	61.7	72.4
Chloride	9.7	12.3	12.9	14.0
Specific Conductance	447.3	537.4	578.7	678.4
Magnesium	8.4	10.3	11.7	15.5
Mercury µg/l (T)	0.0226	NDA	NDA	NDA
Mercury µg/l (D)	NDA	0.13	ND	NDA
pH	8.1	8.2	8.2	8.2
Selenium µg/l (T)	0.5	1.7	1.6	ND
Selenium µg/l (D)	0.5	1.2	0.71	0.67
Sodium	27.6	38.8	41.4	48.0
Sulfate	106.0	137.8	155.5	206.0
Total Dissolved Solids	271.1	305.9	386.6	460.5

[1] Values are arithmetic averages. All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in microSiemens/centimeter (µS/cm); pH in standard units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected; NDA: No Data Available.

Source: USGS-NWIS 2016.



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.1
Selected Water Quality Sampling Locations, Lake Powell and Tributary Rivers

The most downstream gaging location on the San Juan River before it enters Lake Powell is at Bluff, Utah, roughly 45 miles further east of the reservoir. That gaging station is about 90 air miles east of Page, Arizona. The USGS Bluff station (09379500) represents the most regular downstream data collection on the San Juan River above the reservoir. Mean monthly river discharges for the period 1914 – 2014 are indicated in **Table WR-8.9**. The flows are affected by storage at Navajo Lake upstream of Farmington, New Mexico, by municipal and industrial withdrawals, and by irrigation diversions and returns. A comparison of monthly mean flows over time also is indicated in **Table WR-8.9**. More consistent monthly flows are indicated after closure of Navajo Dam in 1962. Generally declining flows are reflected in more recent periods. The 5-year period from 2003 – 2007 reflects conditions during the lowest storage in Lake Powell, and the 2010 – 2014 period reflects more recent river conditions.

Table WR-8.9 Comparative Monthly Mean Flows, San Juan River near Bluff, UT [1]

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1914-2014	1,080	1,360	1,770	3,130	4,900	5,230	2,300	1,680	1,600	1,480	1,180	1,060
1914-1961	709	1,120	1,780	4,250	6,660	7,040	2,850	1,940	1,720	1,520	986	722
1962-1994	1,600	1,840	2,040	2,810	3,900	4,170	2,280	1,590	1,530	1,600	1,530	1,550
1995-2014	873	998	1,300	1,530	3,190	3,550	1,270	1,320	1,480	1,200	958	854
2003-2007	830	956	1,010	1,580	3,630	2,960	980	1,090	1,440	1,580	990	881
2010-2014	712	730	807	953	1,574	1,994	947	1,112	1,433	879	762	696

[1] Monthly mean flows are indicated in cubic feet per second for USGS location 09379500. Navajo Dam was closed in 1962.

Source: USGS-NWIS 2016.

Water quality in the lower San Juan River has also been monitored by the USGS at the Bluff, Utah station. Sampling date summarized below represent the period from November, 1975 to August 2013. Water quality types were primarily mixed, along with some that reflected calcium bicarbonate dominance, and others that reflected sodium sulfate dominance. Bicarbonate concentrations (analyzed only in 56 analyses from 1980 and before) ranged from 91 to 600 mg/L, with a median value of 170 mg/L. Sulfate concentrations in 61 samples over that same period ranged from 67 to 640 mg/L, with a median of 270 mg/L. Calcium was the dominant cation, followed by sodium, and magnesium concentrations were considerably less than either. These values for sulfate, calcium, magnesium, and sodium were similar in samples taken between 2010 and 2013. Over the entire sample suite, Total Dissolved Solids concentrations ranged from 151 to 1,190 mg/L, with a median of 491 mg/L.

Trace element analyses were conducted at different dates, but results included total and dissolved concentrations as well as concentrations in suspended sediment. Many constituents were not detected in these analyses, and the number of samples analyzed with detectable concentrations varied substantially. With these considerations, a summary of results for selected trace elements is indicated in **Table WR-8.10**.

Table WR-8.10 Selected Trace Element Median Concentrations, San Juan River near Bluff, Utah, 1975 - 2013 [1]

	Arsenic	Boron	Cadmium	Chromium	Copper	Lead	Mercury	Selenium	Vanadium	Zinc
Dissolved	1	60	2	1	2	1	0.2	2	6	10
Sediment	2	NDA	2.5	20	16	61	0.15	2	41	66
Total	3	NDA	20	20	30	200	0.1	3	NDA	NDA

[1] Values are medians from multiple samples in µg/L. Concentrations reflect the dissolved fraction, suspended sediment, and total concentrations. NDA: No Data Available.

Source: USGS-NWIS 2016.

WR.8.5 Lake Powell

At a normal water surface elevation, the reservoir has a length of 186 miles and a surface area of 161,390 acres (approximately 252 square miles) (Reclamation 2009). As mentioned previously, the total water storage capacity within Lake Powell is approximately 26 million acre-feet at a pool elevation of 3,700 feet amsl (Ferrari 1988). Of the water volume, approximately 21 million acre-feet is the maximum active capacity. All water used at NGS comes from Lake Powell. Pumped withdrawals from Lake Powell supply the water used at NGS. Five submersible pumps feed two 30-inch lines supplying the generating station. NGS has an annual allocation of 34,100 acre-feet per year (afy) for consumptive use and an allocation for 5,900 afy for non-consumptive use. Over the past 15 years, annual water use at NGS has varied from about 26,000 up to 29,000 afy. Water supplies for Page and LeChee also come from Lake Powell.

The annual consumptive allocation of 34,100 acre-feet at NGS represents approximately 0.16 percent of the active reservoir storage at a pool elevation 3,700 feet. An estimated average actual withdrawal of 27,500 acre-feet per year represents approximately 0.13 percent of active reservoir storage at that elevation, and about 0.10 percent of total reservoir water capacity. The lowest recorded pool elevation for Lake Powell occurred at 3,555.1 feet in early April, 2005. At that elevation, the total reservoir water volume is approximately 9.8 million acre-feet. The total annual allocation for NGS would represent approximately 0.35 percent of that lowest recorded reservoir water volume.

The peak inflow to Lake Powell occurs in April through July, due to snowmelt from the west slope of the Rocky Mountains (Hart et al. 2012). Salt concentrations in river water contributing to Lake Powell decrease during this period, with concentrations generally less than 500 mg/L of Total Dissolved Solids (Hart et al. 2012). With decreasing inflows after mid-summer, salt concentrations increase to more than 1,000 mg/L, due to inflows from arid parts of the basins and related geologic factors. Irrigation return-flows from agricultural lands also contribute salts to the reservoir. Physical and chemical characteristics of Lake Powell reflect these factors through time, and also others such as solar heating, wind and cloud cover (Hart et al. 2012).

Major existing investigations of water and sediment quality in Lake Powell have been conducted by the USGS (Hart et al. 2012, Hornewer 2014, Vernieu 2015). Vernieu discussed historical and current water quality sampling at major stations from 1963 through 2013. Those data consist primarily of chemical analyses for major ions (e.g., sulfate, calcium) and depth profiles of physicochemical parameters through the water column (Vernieu 2015). The investigation by Hornewer analyzed water and sediment samples from the San Juan River delta area of Lake Powell, approximately 45 straight-line miles upstream of NGS and about 62 river miles above Glen Canyon Dam. Three sediment cores of total depths ranging from 1.48 to 4.6 meters (4.85 to 15.1 feet) were retrieved and analyzed for San Juan River delta sediments. Their concentrations are summarized for selected trace element constituents in **Table WR-8.11** below. Sampling locations are depicted in **Figure WR.8--1** above.

Table WR-8.11 Selected Trace Element Average Concentrations in San Juan Delta Sediment Cores [1]

	Arsenic	Boron	Cadmium	Chromium	Copper	Lead	Molybden um	Selenium	Vanadium
Minimum	2.0	34.9	0.07	7.2	6.5	11.2	0.5	<0.7	17.8
Maximum	10.0	131.3	0.49	61.9	48.6	44.8	4.1	1.53	112.0

[1] Values represent averages from 20 to 30 millimeter thick subsamples of 116 total core samples from three cores. All values are in micrograms per gram (µg/g). Mercury was not analyzed.

Source: Hornewer 2014.

At each sediment core location, Hornewer (2014) also retrieved samples from water immediately overlying the water-sediment interface. Selected trace element concentrations for these samples (and subsamples) are summarized in **Table WR-8.12** below.

Table WR-8.12 Selected Trace Element Average Concentrations in San Juan Delta Water Samples [1]

	Arsenic	Boron	Cadmium	Chromium	Copper	Lead	Molybdenum	Selenium	Vanadium
Minimum	1.2	65	<0.002	<0.1	1.4	0.028	3.0	0.7	3.2
Maximum	1.7	86	0.013	0.2	1.6	0.063	4.5	0.9	4.2

[1] Values represent averages of subsamples taken at three different sampling locations. All values are in µg/L. Mercury was not analyzed.

Source: Hornewer 2014.

Hart et al. (2012) collected water quality samples at several Lake Powell locations along the northern perimeter of the cumulative study area. Samples were collected between April 2004 and July 2006. Trace element concentrations for these samples (and subsamples) are characterized in **Table WR-8.13** below.

Table WR-8.13 Selected Trace Element Average Concentrations in Lake Powell Water Samples [1]

Location	Arsenic	Boron	Cadmium	Chromium	Copper	Mercury	Molybdenum	Lead	Selenium	Vanadium	Zinc
Dangling Rope Marina; 1 meter depth	0.04 – 1.91	57 – 82	<0.001 – 0.054	<0.1 – 0.2	0.41 – 1.2	0.5 – 1.0	3.8 – 4.9	<0.07 – 0.043	1.3 – 1.9	1.3 – 1.7	0.1 – 4.7
Antelope Point Marina; 1 meter depth	1.4 – 1.7	73 – 87	<0.001 – <0.004	<0.01 – 0.17	<0.04 – 1.1	0.3 – 1.0	4.6 – 5.2	0.010 – 0.027	1.6 – 2.2	1.4 – 1.8	0.71 – 2.6
Rainbow Bridge; 1 meter depth	1.5 – 1.7	64 – 80	<0.001 – <0.004	<0.1 – 0.24	0.33 – 1.1	0.4 – 1.1	4.2 – 4.7	0.010 – 0.024	1.3 – 1.7	1.3 – 1.9	0.66 – 0.84
Padre Bay; 1 meter depth	1.3 – 1.6	63 – 82	<0.001 – 0.005	<0.1 – 0.24	<0.04 – 1.1	0.3 – 0.9	3.9 – 5.0	0.011 – 0.038	1.3 – 2.0	1.3 – 1.8	0.4 – 1.2

[1] Values represent ranges in averages from water subsamples at the locations noted. All values are in µg/L, except mercury in nanograms per liter (ng/l).

Source: Hart et al. 2012.

Available information for selenium concentrations in Lake Powell water also has been investigated through state data. Queries to the states (ADEQ, UDEQ) identified additional selenium data for Lake Powell from the Utah state monitoring efforts. Recent (2009 through 2012) selenium concentrations in the water ranged between 1.01 and 3.69 µg/L, with an average concentration of 1.89 µg/L for 13 samples taken by UDEQ. The median concentration was 1.82 µg/L. Dissolved selenium in several water samples taken from below Glen Canyon Dam had concentrations of 3 or 4 µg/L (USGS-NWIS 2016). Selenium concentrations ranged from less than 0.8 to 4.3 micrograms per gram (µg/g) in USGS sediment cores retrieved from widespread locations in the lake (Hart et al. 2005).

In August 2015, there was an accidental spill from the abandoned Gold King Mine on Cement Creek (a tributary to the Animas River) near Silverton, Colorado. Approximately 3 million gallons (9.2 acre-feet) of contaminated water drained down the Animas into the San Juan River, and eventually into Lake Powell. The mine had not been active since 1922, and was a known source of poor quality water (USEPA 2015b). Water retained in the mine forms sulfuric acid. This dissolves naturally-occurring heavy metals such as zinc, lead, cadmium, copper and aluminum within the mine, and elevates these constituents in mine drainage (USEPA 2015b). For selected constituents of interest, USEPA water and sediment sampling results for August 15 and 16, 2015, are indicated below (**Table WR-8.14**) at different downstream locations after the spill. While some dates had multiple USEPA samples taken and others did not analyze mercury, the data depict the general levels of these constituents at their locations. The lead concentration at Page indicated below may be an anomaly or a data-recording error. River values were generally higher than in the reservoir, and also generally higher than in the San Juan River delta samples taken by Hornewer above (**Table WR-8.12**).

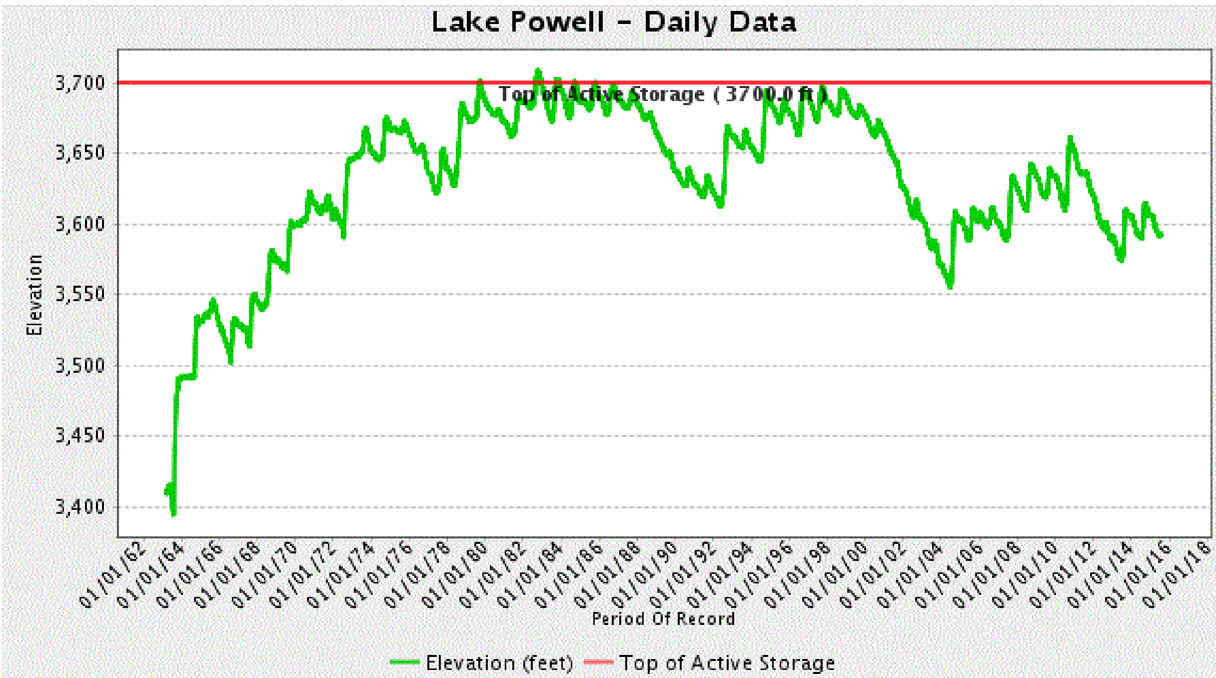
Table WR-8.14 USEPA Analyses after the Gold King Mine Spill [1]

Medium	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Molybdenum	Selenium	Vanadium
SJBB (San Juan River below Bluff UT)									
Water 8/16	2.8	0.25	3.3	7.2	5.9	0.1	1.9	0.5	10
SJIN2 (San Juan Inflow 2)									
Water 8/15	5	0.43	4.7	14	13		2	1.0	31
Sediment 8/15	4	0.15	14	15	14	0.019	0.29	0.25	27
LPGB (Lake Powell at Gunsight Butte)									
Water 8/16	1.5	0.04	0.88	0.83	0.1		3.8	1.4	2.2
Sediment 8/16	0.095	0.026	2.4	1.4	2	0.009	0.041	0.16	5
LPNC (Lake Powell within Navajo Canyon)									
Water 8/16	1.6	0.11	0.88	0.69	0.1		4.6	1.2	1.5
PAGE									
Water 8/16	1.4	0.1	1.7	4.9	14	0.06	3.9	2.0	1.3
LPDAM (Lake Powell at Glen Canyon Dam)									
Water 8/16	1.6	0.04	0.88	0.92	0.1		4.8	1.6	1.7

[1] All values are total concentrations. Water concentrations in µg/L; sediment concentrations in milligrams per kilogram. Empty cells indicate no available data.

Source: USEPA 2015b.

Pool retention in Lake Powell has raised water levels to well above those in the historic Colorado River in Glen Canyon. The pool elevation (the elevation of the water surface) in Lake Powell changes daily, with generally seasonal patterns according to managed release schedules. **Figure WR.8-2** below indicates these variations, and **Table WR.8-15** depicts more recent variations.



Source: Reclamation 2016a.

Figure WR.8-2 Historic Pool Elevations at Lake Powell

Table WR.8-15 Recent Maximum and Minimum Pool Elevations, Lake Powell

Water Year	High Pool Elevation (feet msl) / Month of Occurrence	Low Pool Elevation (feet msl) / Month of Occurrence
WY 2010	3,638.8 (July)	3,618.6 (April)
WY 2011	3,660.9 (July)	3,609.7 (April)
WY 2012	3,652.9 (October 2011)	3,621.6 (September)
WY 2013	3,621,5 (October 2012)	3,589.1 (September)
WY 2014	3,609.7 (July)	3,574.2 (April)
WY 2015	3,614,3 (July)	3,589.8 (May)

Source: Reclamation 2016b.

The elevated water levels in Lake Powell create a groundwater gradient into the N-Aquifer along the reservoir perimeter. Recharge from Lake Powell may change groundwater quality in the N Aquifer, including increased TDS. The potential changes are expected to lag the observed hydraulic water level response. The timeframe for such a potential effect will depend on the degree of fracture flow through the Navajo Sandstone. Groundwater investigations in a deep well at NGS suggest that although some fracture flow occurs, there is no evidence of extensive fracture flow throughout the Navajo Sandstone at that site. N-Aquifer groundwater in the NGS vicinity is approximately 900 feet below the ground surface, and isolated by the Carmel Formation and several hundred feet of dry sandstone. Water levels in the deep wells at NGS are rising about 1 or 2 feet per year, likely due to recharge from Lake Powell.

WR.8.6 Colorado River (Upstream and Downstream of Lake Powell)

Mean annual flow rates (cfs) for the Colorado River downstream of Lake Powell are indicated in **Table WR-8-16** below. Average monthly flows for the 1921 to 1962 period reflect the wider variations between winter low flows and summer peak flows before the construction of Glen Canyon Dam in the early 1960s. More steady flows are indicated in releases after dam closure in 1963. The periods since 1995 indicate changes in reservoir releases due to operating conditions and regional drought. In particular, the period from 2003 to 2007 reflects management through the historic lowest pool storage for Lake Powell in 2005. Some recent recovery is reflected in the 2010 to 2014 data compared to the previous period.

Table WR-8.16 Comparative Monthly Mean Flows, Colorado River near Lees Ferry, AZ [1]

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921-2014	9,840	9,860	10,500	15,800	27,300	32,000	18,200	13,300	10,900	9,550	9,850	9,700
1921-1962	5,260	6,720	9,250	19,900	44,200	52,400	21,200	10,400	8,280	8,230	7,440	5,840
1963-1994	13,000	11,800	10,700	13,000	15,000	16,900	16,100	15,600	13,600	10,300	11,300	12,200
1995-2014	14,200	13,300	12,800	12,000	12,400	14,400	15,400	15,400	11,800	11,200	12,500	13,800
2003-2007	13,100	13,100	11,900	10,100	10,000	13,800	14,200	14,300	8,960	8,980	10,000	12,000
2010-2014	14,300	12,400	11,000	10,900	11,400	13,900	15,900	15,500	10,600	10,000	13,900	14,200

[1] Monthly mean flows are indicated in cubic feet per second for USGS location 09380000. Glen Canyon Dam was closed in March, 1963.

Source: USGS-NWIS 2016.

For the Colorado River upstream and downstream of Lake Powell, both USGS and Utah Department of Environmental Quality (UDEQ), Division of Water Quality data were accessed for water quality data in selected locations. Results are indicated in **Tables WR-8.17** through **WR-8.20** below. Available data for arsenic, mercury, and selenium typically reflect fairly low values, within concentrations common to the region. The total mercury concentration in one sample on the river near Grand Canyon (USGS gage 09402500, **Table WR-8.20**) was higher than in other samples elsewhere. It remained within acute criteria for aquatic and wildlife habitat, however. Dissolved mercury concentrations were not detected.

Table WR-8.17 Upstream Water Quality Summary, Colorado River below Big Drop #3 Rapids (upstream of Lake Powell), 2000 through 2014 [1]

Chemical Constituent	Total Analyses Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value
Aluminum, µg/l (D)	76	22	10.6	505.0	67.1	41.3
Arsenic, µg/l (D)	76	18	1.01	3.10	1.56	1.44
Bicarbonate	80	0	107.0	573.0	189.1	167.0
Boron, µg/l	52	0	34.7	194.6	80.0	74.8
Cadmium, µg/l (D)	76	75	0.146	0.146	0.146	0.146
Calcium	79	0	33.7	283.8	81.0	64.5
Chloride	80	3	10.1	240.0	62.9	53.7
Chromium, µg/l (D)	76	69	2.04	5.70	3.36	2.55
Copper, µg/l (D)	76	28	1.31	94.50	5.76	2.12
Iron, µg/l (D)	76	52	11	90.60	47.75	48.75
Lead, µg/l (D)	76	62	0.103	0.81	0.27	0.165
Magnesium	79	0	10.1	93.0	26.8	22.8
Manganese, µg/l (D)	76	71	5.56	29.20	12.90	6.95
Mercury, µg/l (D)	76	76	ND	ND	N/A	N/A
$NO_3 + NO_2$	78	5	0.0295	2.28	0.45	0.37
pH	57	0	7.32	8.83	8.20	8.28
Selenium, µg/l (D)	76	18	1.01	12.6	3.1	2.6
Sodium	79	0	19.5	275.4	74.6	64.7
Specific Conductance	57	0	338	5,184	1,180	941
Sulfate	80	0	62	3,460	258	179
Total Dissolved Solids	78	0	198	2,076	596	490
Total Suspended Solids	78	0	8	20,960	984	511
Zinc, µg/l (D)	76	58	10.1	52.5	16.0	13.05

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Specific Conductance in micromhos/centimeter (µmhos/cm); pH in standard units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). N/A: Not Applicable. ND: Not Detected.

Source: Utah Department of Environmental Quality, Division of Water Quality 2015.

Table WR-8.18 Upstream Water Quality Summary, Colorado River above Dark Canyon (upstream of Lake Powell), 2000 through 2008 [1]

Chemical Constituent	Total Analyses Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value
Aluminum, µg/l (D)	32	27	10.9	3,360	1,058	491
Arsenic, µg/l (D)	32	13	1.2	2.71	1.79	1.70
Bicarbonate	31	0	118	412	200	197
Boron, µg/l	12	0	46.1	164.0	97.1	91.2
Cadmium, µg/l (D)	32	32	ND	ND	N/A	N/A
Calcium	31	0	40.6	174.8	86.5	86.3
Chloride	31	0	12.6	160.0	73.1	75.3
Chromium, µg/l (D)	32	28	2.18	7.60	3.84	2.795
Copper, µg/l (D)	32	26	1.34	2.290	1.592	1.505
Iron, µg/l (D)	32	25	21.4	5,160	1,311	56.6
Lead, µg/l (D)	32	30	0.221	9.00	4.61	4.61
Magnesium	31	0	12.4	70.8	30.3	32.1
Manganese, µg/l (D)	32	7	6.6	158	32.6	24.6
Mercury, µg/l (D)	32	32	ND	ND	N/A	N/A
$NO_3 + NO_2$	29	2	0.13	1.4	0.51	0.4
pH	31	0	7.42	8.84	8.11	8.14
Selenium, µg/l (D)	32	1	1.19	6.8	3.2	3.0
Sodium	31	0	23.8	214.0	90.7	97.7
Specific Conductance	31	0	472	4,338	1,847	2,016
Sulfate	31	1	69.9	34,000	1,385	250
Total Dissolved Solids	31	0	258	1,384	662	680
Total Suspended Solids	31	0	28	2,925	905	340
Zinc, µg/l (D)	32	26	12.2	32.9	17.4	14.6

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Specific Conductance in micromhos/centimeter (µmhos/cm); pH in standard units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). N/A: Not Applicable. ND: Not Detected.

Source: Utah Department of Environmental Quality, Division of Water Quality 2015.

Table WR-8.19 Downstream Water Quality Summary, Colorado River at Lee's Ferry, 2010 – 2015 [1]

Chemical Constituent	Total Analyses Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value
Arsenic, µg/l (T)	22	0	1.4	2.7	1.7	1.5
Arsenic, µg/l (D)	58	0	1.0	1.7	1.4	1.4
Bicarbonate	55	0	138	184	159.16	160
Boron, µg/l	47	0	56	93	76	74
Cadmium, µg/l (T)	22	20	0.02	0.04	0.03	0.03
Cadmium, µg/l (D)	26	17	0.00	0.05	0.02	0.02
Calcium	58	0	54.0	79.4	66.4	65.9
Chloride	58	0	28.8	62.9	46.6	46.4
Chromium, µg/l (T)	22	20	0.40	0.43	0.42	0.42
Chromium, µg/l (D)	7	5	0.05	0.09	0.07	0.07
Specific Conductance	56	0	579	900	754.64	750.50
Copper, µg/l (T)	22	11	0.71	4.20	1.36	1.10
Copper, µg/l (D)	26	7	0.70	3.40	1.10	0.92
Fluoride	58	0	0.20	0.33	0.27	0.28
Lead, µg/l (T)	22	13	0.04	0.38	0.16	0.13
Lead, µg/l (D)	26	15	0.01	0.10	0.04	0.03
Magnesium	58	0	18.0	25.5	21.4	21.1
Manganese (T)	23	0	0.70	10.80	1.90	1.20
Manganese (D)	7	0	0.56	2.58	1.26	0.67
Mercury, µg/l (T)	19	19	ND	ND	N/A	N/A
Nitrate	47	0	0.15	0.39	0.28	0.28
Nitrite	44	31	0.001	0.0030	0.0016	0.0020
$NO_3 + NO_2$	55	0	0.148	0.386	0.282	0.280
pH	55	0	7.90	8.30	8.17	8.20
Sediment, Suspended	48	0	1	177	9	2
Selenium, µg/l (T)	22	0	1.19	1.71	1.43	1.41
Selenium, µg/l (D)	47	0	1.30	2.20	1.69	1.60
Sodium	58	0	43.6	78.8	61.3	61.7
Solids, Dissolved	52	0	374	597	499	494
Sulfate	58	0	136	233	186	184
Vanadium, µg/l (T)	3	0	2.3	2.6	2.4	2.3
Vanadium, µg/l (D)	47	0	1.4	1.9	1.6	1.6
Zinc (T)	22	21	4.4	4.4	4.4	4.4
Zinc (D)	26	23	0.29	0.55	0.44	0.48

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in microSiemens/centimeter (µS/cm); pH in standard units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). N/A: Not Applicable. ND: Not Detected.

Source: USGS-NWIS 2016.

Table WR-8.20 Downstream Water Quality Summary, Colorado River near Grand Canyon, 2014 and 2015 [1]

Chemical Constituent	Total Analyses Count	Not Detected Count	Lowest Detected Value	Highest Value	Average Value	Median Value
Arsenic µg/l (T)	2	0	1.9	4.7	3.3	3.3
Arsenic µg/l (D)	2	0	1.3	1.6	1.45	1.45
Bicarbonate	2	0	167	179	173	173
Calcium	2	0	68.3	77.8	73.0	73.0
Chloride	2	0	82.9	85.2	84.0	84.0
Specific Conductance	2	0	883	955	919	919
Magnesium	2	0	22.1	25.1	23.6	23.6
Mercury µg/l (T)	2	1	0.038	0.038	0.038	0.038
Mercury µg/l (D)	2	2	ND	ND	ND	ND
pH	2	0	8.2	8.3	8.25	8.25
Selenium µg/l (T)	2	0	1.55	1.63	1.59	1.59
Selenium µg/l (D)	0	0	NDA	NDA	NDA	NDA
Sodium	2	0	86.3	99.4	92.8	92.8
Sulfate	2	0	199	211	205	205
Total Dissolved Solids	2	0	565	622	594	594

[1] All units in milligrams per liter (mg/l) unless otherwise noted as micrograms per liter (µg/l). Electrical conductivity in microSiemens/centimeter (µS/cm); pH in standard units. Concentrations represent the Dissolved fraction (D) unless otherwise noted as Total recoverable (T). ND: Not Detected; NDA: No Data Available.

Source: USGS-NWIS 2016.

WR.8.7 Summary of Recent Regional Background Water Quality from Project-Related Sampling

Additional background surface water sampling was recently conducted in the study regions by ENVIRON for purposes of an Ecological Risk Assessment (ERA) (Ramboll Environ 2016a,b,c,e). Results are summarized in **Table WR-8.21** below.

Table WR-8.21 Surface Water Trace Metals Data Used for the NGS Baseline Risk Assessments

Constituent	Water Source/Risk Assessment	Minimum (mg/L)	Maximum (mg/L)	Mean (mg/L)	95% UCL (mg/L)
Dissolved					
Arsenic	NGS Near-field (20-km) ERA[1]	0.0006	0.0028	0.0015	0.0015
	San Juan River ERA[2]	---	0.0440	0.0022	0.0027
	Northeast Gap Region ERA[3]	---	0.0095	0.0017	0.0018
	Southwest Gap Region ERA[3]	---	0.0023	0.0019	0.0021
	Colorado River for HHRA[4]	0.0013	0.0028	0.0018	0.0020
	Lake Powell for HHRA[4]	0.0006	0.0025	0.0014	0.0015
Mercury	NGS Near-field (20-km) ERA	ND	ND	ND	ND
	San Juan River ERA	---	0.0016	0.00016	0.00021
	Northeast Gap Region ERA	---	0.00024	0.00002	0.00003
	Southwest Gap Region ERA	---	0.000003	0.000007	0.000002
	Colorado River for HHRA	ND	ND	ND	ND
	Lake Powell for HHRA	ND	ND	ND	ND
Methylmercury	NGS Near-field (20-km) ERA	---	---	---	---
	San Juan River ERA	---	---	---	---
	Northeast Gap Region ERA	---	---	---	---
	Southwest Gap Region ERA	---	---	---	---
	Colorado River for HHRA	NA	NA	NA	NA
	Lake Powell for HHRA	NA	NA	NA	NA
Selenium	NGS Near-field (20-km) ERA	0.0007	0.0036	0.0014	0.0016
	San Juan River ERA	---	0.012	0.0011	0.0012
	Northeast Gap Region ERA	---	0.0065	0.0024	0.0025
	Southwest Gap Region ERA	---	0.0030	0.0015	0.0024
	Colorado River for HHRA	0.0014	0.0030	0.0023	0.0024
	Lake Powell for HHRA	0.0007	0.0036	0.0019	0.0015
Total					
Arsenic	NGS Near-field (20-km) ERA	0.0010	0.0022	0.0015	0.0015
	San Juan River ERA	---	0.002	0.002	NA[5]
	Northeast Gap Region ERA	---	0.0016	0.0015	0.0015
	Southwest Gap Region ERA	---	0.028	0.0098	0.86[6]
	Colorado River for HHRA	0.0010	0.0019	0.0014	0.0015
	Lake Powell for HHRA	0.0013	0.0022	0.0016	0.0016
Mercury	NGS Near-field (20-km) ERA	ND	ND	ND	ND
	San Juan River ERA	---	0.0006	0.000049	0.000046
	Northeast Gap Region ERA	ND	ND	ND	ND
	Southwest Gap Region ERA	ND	ND	ND	ND
	Colorado River for HHRA	ND	ND	ND	ND
	Lake Powell for HHRA	ND	ND	ND	ND

Table WR-8.21 Surface Water Trace Metals Data Used for the NGS Baseline Risk Assessments

Constituent	Water Source/Risk Assessment	Minimum (mg/L)	Maximum (mg/L)	Mean (mg/L)	95% UCL (mg/L)
Methylmercury	NGS Near-field (20-km) ERA	0.00000003	0.00000021	0.000000028	0.000000039
	San Juan River ERA	---	---	---	---
	Northeast Gap Region ERA	---	0.00000003	0.000000017	NA[5]
	Southwest Gap Region ERA	---	0.00000004	0.000000019	NA[5]
	Colorado River for HHRA	0.00000004	0.00000004	0.000000040	NA[5]
	Lake Powell for HHRA	0.00000003	0.00000021	0.000000098	0.000000057
Selenium	NGS Near-field (20-km) ERA	0.0011	0.0051	0.0017	0.0020
	San Juan River ERA	---	0.0050	0.0012	0.0010
	Northeast Gap Region ERA	---	0.0051	0.0020	0.0026
	Southwest Gap Region ERA	---	0.0120	0.0040	0.0130[6]
	Colorado River for HHRA	0.0012	0.0023	0.0018	0.0020
	Lake Powell for HHRA	0.0011	0.0051	0.0024	0.0023

[1] Field data collected in 2014. Summary values from Tables A-1A-1 and A-1A-2 in the NGS Near-field ERA. Maximum, mean, and 95 percent UCL values used as baseline surface water model input values (i.e., exposure point concentrations [EPCs]) used to calculate the HQ maximum, HQ average, and HQ refined values, respectively (Tables A-4A and A-4B) (Ramboll Environ 2016a).

[2] Summary values from Table A-2A in the San Juan River ERA (Ramboll Environ 2016b) represent a compilation of available data from literature. Maximum, mean, and 95 percent UCL values used as baseline surface water model input values (EPCs) to calculate the maximum, average, and refined HQ values, respectively (Tables A-3A and A-3B). “Historical data were compiled for the area within the boundaries of the San Juan River from State Route 371 Bridge in Farmington, NM, downstream to the San Juan arm of Lake Powell. Samples collected within 20 years were preferred, but older data were included to ensure sufficient sample sizes.” (Ramboll Environ 2016b).

[3] Summary values from Table A-2A in the NGS Gap Region ERA (Ramboll Environ 2016c) represent a compilation of field data collected in 2014 and available data from the USGS Water Quality Portal Database. USGS locations are identified on Figure 4 of the NGS Gap Regions ERA. Maximum, mean, and 95 percent UCL values used as baseline surface water model input values (EPCs) to calculate the maximum, average, and refined HQ values, respectively (Tables A-3A and A-3B) (Ramboll Environ 2016c).

[4] Summary values and calculations for recreational user in Colorado River and Lake Powell within 20 km of NGS provided in the NGS HHRA on Table B4 and B5, respectively (see Figures 5-1 and 5-3 of NGS HHRA for sample locations and watersheds). Calculated 95 percent UCL values were used as baseline model surface water input values to calculate the NGS HHRA HQ values (Table 5-8b in Ramboll Environ 2016e).

[5] Not enough samples measured or detected for this constituent to allow for calculation of 95 percent UCL value; therefore, maximum value used for baseline refined model input value.

[6] The 95 percent UCL was greater than maximum concentration; therefore, maximum value used for baseline refined model input value.

mg/L = milligrams per liter.

NA = Not analyzed / not applicable.

ND = Not detected.

WR.8.8 Stream Crossings along NGS Transmission System Alignments

The NGS transmission system crosses numerous stream channels between the power generation station and the project termination locations at McCullough and Westwing (see **Figure 2A-8** in EIS Chapter 2). Most of these channels are normally dry desert washes that only exhibit short-term flows in response to intense rainfall. With severe rainfall, damaging flash floods may occur in the streams.

The principal stream crossings along the alignments are listed below in **Table WR.8-22**. Numerous smaller channels, mostly unnamed, also occur. Several of the listed crossings are located in deep canyons, where the stream corridor is several hundred feet below the transmission lines, tower structures, and access roads. In these cases, transmission system features are located well away from the channels themselves, even though their paths intersect geographically. Such crossings include Antelope Creek, the Colorado River, Little Colorado River, the Virgin River, and others. All of the stream crossings are spanned by elevated transmission lines; no lines or structures are physically located in principal channels.

Table WR.8-22 Principal Surface Flow Features along the NGS Transmission System

Stream, River, or Flow Path	Flow Duration or Type	Hydrologic Unit Code [2]	Watershed Name	Listed Water Quality Impairments at Crossing Location [3]
NGS to McCullough Transmission Corridor [1]				
Antelope Creek	Intermittent or Ephemeral	14070006	Lower Lake Powell. AZ, UT	None Listed
Big Sand Wash	Intermittent or Ephemeral	15010003	Kanab. AZ, UT	None Listed
Bitter Seeps Wash	Intermittent or Ephemeral	15010003	Kanab. AZ, UT	None Listed
Colorado River	Perennial	14070006	Lower Lake Powell. AZ, UT	Selenium
Clayhole Wash	Intermittent or Ephemeral	15010009	Fort Pierce Wash. AZ, UT	None Listed
Dutchman Wash	Intermittent or Ephemeral	15010009	Fort Pierce Wash. AZ, UT	None Listed
Gypsum Wash	Intermittent or Ephemeral	15010005	Lake Mead. AZ, NV	None Listed
Halfway Wash	Intermittent or Ephemeral	15010010	Lower Virgin. AZ, NV, UT	None Listed
Kaibab Wash	Intermittent or Ephemeral	15010003	Kanab. AZ, UT	None Listed
Kanab Creek	Intermittent or Ephemeral	15010003	Kanab. AZ, UT	None Listed
Las Vegas Wash	Perennial	15010015	Las Vegas Wash. NV	None Listed (below treatment plants)
Meadow Valley Wash	Perennial	15010013	Meadow Valley Wash. NV, UT	Fluoride, Temperature, pH, Mercury in Fish Tissue
Mokaac Wash	Intermittent or Ephemeral	15010010	Lower Virgin. AZ, NV, UT	None Listed
Muddy River	Perennial	15010012	Muddy. NV	Selenium, Iron, Dissolved Oxygen, Temperature, Fecal Coliform, others

Table WR.8-22 Principal Surface Flow Features along the NGS Transmission System

Stream, River, or Flow Path	Flow Duration or Type	Hydrologic Unit Code [2]	Watershed Name	Listed Water Quality Impairments at Crossing Location [3]
Paria River	Perennial	14070007	Paria. AZ, UT	*E. coli*, Sedimentation/Siltation
Pipe Valley Wash	Intermittent or Ephemeral	15010003	Kanab. AZ, UT	None Listed
Sand Hollow Wash	Intermittent or Ephemeral	15010010	Lower Virgin. AZ, NV, UT	None Listed
Sandridge Wash	Intermittent or Ephemeral	15010009	Fort Pierce Wash. AZ, UT	None Listed
Toquop Wash	Intermittent or Ephemeral	15010010	Lower Virgin. AZ, NV, UT	None Listed
Virgin River	Perennial	15010010	Lower Virgin. AZ, NV, UT	None Listed
Weiser Wash	Intermittent or Ephemeral	15010012	Muddy. NV	None Listed
Welcome Creek	Intermittent or Ephemeral	15010010	Lower Virgin. AZ, NV, UT	None Listed
White Sage Wash	Intermittent or Ephemeral	15010003	Kanab. AZ, UT	None Listed
NGS to Westwing Transmission Corridor [1]				
Agua Fria River	Intermittent or Ephemeral, some Perennial sections	15070102	Agua Fria. AZ	*Escherichia coli (E. coli*)
Big Bug Creek	Perennial	15070102	Agua Fria. AZ	None Listed
Bishop Creek	Intermittent or Ephemeral	15070102	Agua Fria. AZ	None Listed
Cataract Creek	Intermittent or Ephemeral	15010004	Havasu Canyon. AZ	None Listed
Caterpillar Tank Wash	Intermittent or Ephemeral	15070102	Agua Fria. AZ	None Listed
Cedar Wash	Intermittent or Ephemeral	15020016	Lower Little Colorado. AZ	None Listed
Fivemile Wash	Intermittent or Ephemeral	15020018	Moenkopi Wash. AZ	None Listed
Hamblin Wash	Intermittent or Ephemeral	15020018	Moenkopi Wash. AZ	None Listed
Johnson Creek	Intermittent or Ephemeral	15060201	Big Chino-Williamson Valley. AZ	None Listed
Lava Wash	Intermittent or Ephemeral	15020016	Lower Little Colorado. AZ	None Listed
Little Colorado River	Intermittent or Ephemeral	15020016	Lower Little Colorado. AZ	None Listed
Little Squaw Creek	Intermittent or Ephemeral	15070102	Agua Fria. AZ	None Listed

Table WR.8-22 Principal Surface Flow Features along the NGS Transmission System

Stream, River, or Flow Path	Flow Duration or Type	Hydrologic Unit Code [2]	Watershed Name	Listed Water Quality Impairments at Crossing Location [3]
Meath Wash	Intermittent or Ephemeral	15060202	Upper Verde. AZ	None Listed
Miller Wash	Intermittent or Ephemeral	15010004	Havasu Canyon. AZ	None Listed
Needmore Wash	Intermittent or Ephemeral	15020016	Lower Little Colorado. AZ	None Listed
Rattlesnake Wash	Intermittent or Ephemeral	15060202	Upper Verde. AZ	None Listed
Red Lake Wash	Intermittent or Ephemeral	15010004	Havasu Canyon. AZ	None Listed
Spring Valley Wash	Intermittent or Ephemeral	15010004	Havasu Canyon. AZ	None Listed
Squaw Creek	Intermittent or Ephemeral	15070102	Agua Fria. AZ	None Listed
Tank Creek	Intermittent or Ephemeral	15070102	Agua Fria. AZ	None Listed
Twin Buttes Wash	Intermittent or Ephemeral	15070102	Agua Fria. AZ	None Listed
Verde River	Perennial	15060202	Upper Verde. AZ	None Listed
Wagon Tire Wash	Intermittent or Ephemeral	15060202	Upper Verde. AZ	None Listed
Yarber Wash	Intermittent or Ephemeral	15070102	Agua Fria. AZ	None Listed

[1] General alignments are shown in Chapter 2, Figure 2A-8.

[2] U.S. Geological Survey Hydrologic Units (Seaber et al. 1987).

[3] For stream segments at Transmission System crossings. USEPA 2016.

Source: National Hydrographic Data Set, USEPA 2016.

WR.8.9 Regional Springs and Wells from Younger Geologic Formations

There are approximately 320 other known spring locations on Black Mesa that have geologic sources in younger Cretaceous rocks or unconsolidated deposits. These locations are supplied by groundwater from the alluvium, Yale Point Sandstone, Wepo Formation, Toreva Formation, or other water-bearing zones within the upper portion of the stratigraphic section (see main text **Figure 3.7-4**). Many other springs issue from the D-Aquifer or the older N-Aquifer at the base of the mesa, along deeply incised canyons on the mesa itself, or in more distant canyon and plateau topography far from the coal lease areas. These D- and N-Aquifer locations are described in other text sections specific to those aquifers.

Based on available data, most of the water quality and flow monitoring conducted by tribal organizations or the USGS occurs at lower elevations on Black Mesa, generally between ten and 25 miles from the coal lease areas (National Water Quality Monitoring Council 2015). Based on site locations and geologic mapping, almost all of the springs sampled by tribal organizations or the USGS reflect Toreva Formation or N-Aquifer groundwater sources. Several spring locations south or southwest of the coal leases are probably in Wepo Formation or lower Wepo/Toreva Formation geologic settings. In the Big Mountain area there are several springs probably sourced from the Wepo Formation. These are southwest and “down-section” stratigraphically from the coal lease area. They have TDS concentrations ranging from about 175 to 470 mg/L, and sulfate concentrations ranging from about 20 to 100 mg/L.

Toreva Formation springs are more commonly monitored on Black Mesa. They typically have low TDS and sulfate concentrations, as well as low concentrations of other constituents, except where there may be a hydraulic connection to the Mancos Formation. Springs more typical of Toreva Formation settings have TDS concentrations ranging from 150 to 1,300 mg/L, and sulfate concentrations ranging from about 30 to 280 mg/L. In Toreva Formation settings close to Mancos Formation outcrops, spring water quality has TDS concentrations ranging from about 900 to 3,300 mg/L, and sulfates range from about 300 to 2,200 mg/L (National Water Quality Monitoring Council 2015).

Investigations undertaken for the Hopi Tribe identified approximately 400 springs on Hopi tribal lands or nearby (ADWR 2008). Roughly 55 of these were duplicate locations, outside the reservation boundary, or previously identified as wells. Some are dry. All of the known (claimed) springs were identified as being used for ceremonial purposes; other uses include stock watering, agricultural irrigation, and domestic water supply. Of the identified and verified springs, approximately 50 originate from recent alluvial or colluvial deposits, and about 100 originate from bedrock of the Mesa Verde Group (bedrock stratigraphy is indicated on main text **Figure 3.7-4**). Reported discharges from the alluvial springs ranged from 0 to 25 gallons per minute, with total flows ranging from 21 to 72 gallons per minute. Reported discharges from colluvial springs ranged from 0 to 8 gallons per minute, with total flows ranging from 3 to 20 gallons per minute. Reported discharges from Mesa Verde Group springs ranged from 0 to 50 gallons per minute, with total flows ranging from 99 to 202 gallons per minute. Approximately 160 verified springs originate from unknown sources. Water quality issues at springs with data mainly relate to exceedances of drinking water criteria, including nitrates, TDS, and sulfates (ADWR 2008).

Approximately 75 wells are built in the alluvium or Mesa Verde Group on Hopi tribal lands (ADWR 2008). For wells having water quality data, constituents that exceeded drinking water standards included nitrates, TDS, and sulfate. Sulfate concentrations also occasionally exceeded livestock watering criteria in alluvial wells (ADWR 2008).

WR.8.10 Regional D-Aquifer Characteristics and Uses

Within the broader cumulative study area, D-Aquifer characteristics generally correspond to those described previously at and near the KMC. D-Aquifer recharge generally occurs from precipitation along the eastern boundary of the aquifer. Groundwater flows south, west, and north and discharges into springs on the eastern and northern edges of the aquifer and into the alluvium of Polacca, Oraibi, and Dinnebito Washes along the southwest aquifer boundary, and Moenkopi Wash to the west. This discharge is consumed by plants or lost to evaporation and is not seen as surface flow. Pre-development (pre-1966) groundwater elevation and flow direction are shown on **Figure WR-8.3.**

The D-Aquifer, unlike the N-Aquifer, is not used extensively for municipal supply; consequently water level data are sparse and not monitored regularly. As stated previously, groundwater modeling for PWCC has indicated that the greatest changes in D-Aquifer water levels are within the PWCC leasehold. Simulated 2012 water levels are shown on **Figure WR-8.4**.

Investigations undertaken for the Hopi Tribe identified approximately 5 springs emanating from the D-Aquifer on Hopi tribal lands ADWR 2008). Total dissolved solids were identified as exceeding drinking water criteria for springs where water quality data were available. Reported discharges from D-Aquifer springs ranged from less than 0.2 gallons per minute up to 2.0 gallons per minute, and totaled from 2 to 4 gallons per minute (ADWR 2008). Approximately 60 wells have been developed in the D-Aquifer on Hopi Tribal lands. It is likely that some of these are dry or abandoned. Sulfates and TDS were noted as drinking water exceedances in wells that had data, and fluoride exceedances of both drinking water and livestock watering criteria were noted (ADWR 2008).The estimated saturated thickness of the D-Aquifer varies from zero near the edges of Black Mesa to over 1,700 feet in the deepest parts (GeoTrans 1999).

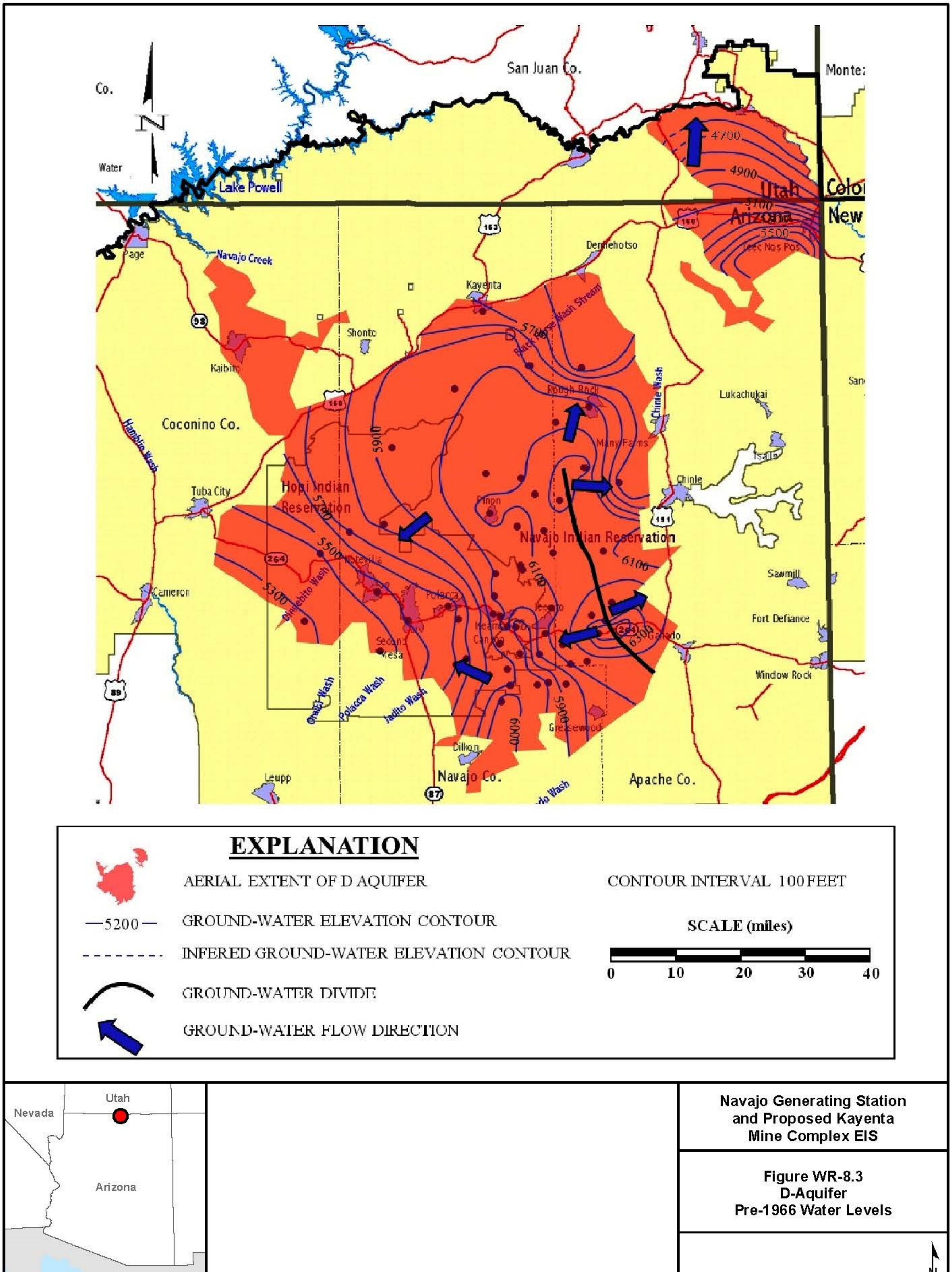
The total amount of water in storage is estimated to be 15 million acre-feet (ADWR 1989). Well yields are estimated to range from 10 to 25 gallons per minute (PWCC 2012 et seq.), or regionally from about 3 to 40 gallons per minute depending on the formation (Cooley et al. 1969). While approximately 125 D-aquifer wells are located within the cumulative study area and provide a reliable source of water to local residents, most of the pumping is outside of the KMC study area. Communities pumping from the confined D-Aquifer include Kitsillie and Spider Mound. Estimated withdrawal by these community systems is approximately 22 acre-feet/year (Tetra Tech 2011).

Groundwater from the D-Aquifer discharges to springs and streams where the aquifer changes from confined to unconfined conditions. The USGS recently undertook a study to identify and characterize springs identified by various sources. Two locations characterized as “likely” springs, based on analysis of imagery and aerial photography, were identified as emanating from D-Aquifer stratigraphic units. The sites were not visited and no flow data are available. However, subsequent to the USGS inventory efforts, some sites were visited during an inter-agency project field trip in early April 2016. That trip was made to both N-Aquifer and D-Aquifer spring and seep sites as part of field verifications for the water resources monitoring program. Due to the sacred nature of some springs to the Navajo and Hopi people, the locations of all of these springs are not published. They will, however, be included in the assessment of potential impacts due to projected groundwater withdrawals.

The USGS operates four stream gages on Black Mesa. These gages measure baseflow (groundwater discharge) and runoff from precipitation and snowmelt. Location of the stream gages are shown on **Figure WR-8.-5** in relation to the boundaries of the D-and N-Aquifers. Data on the Black Mesa stream gages are given in **Table WR-8.23**.

Table WR-8.23 USGS Black Mesa Stream Gages

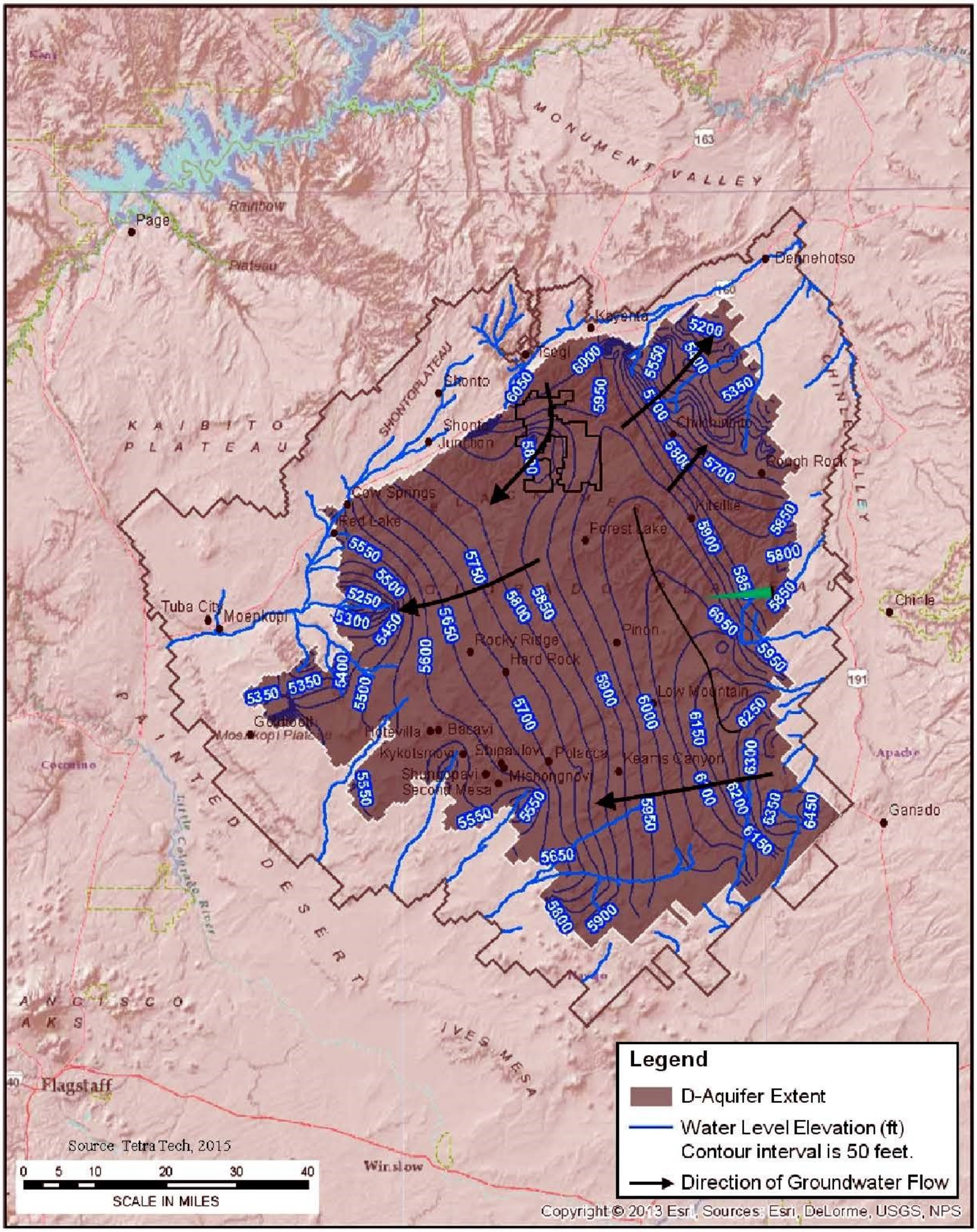
Stream	Station Number	Date Data Collection Began	2011 Median Winter Flow (cfs)
Moenkopi Wash at Moenkopi	09401260	July 1976	1.9
Dinnebito Wash near Sand Springs	09401110	June 1993	0.38
Polacca Wash near Second Mesa	09400568	April 1994	0.14
Pasture Canyon Springs	09401265	August 2004	0.36



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.3
D-Aquifer
Pre-1966 Water Levels

7/20/2016

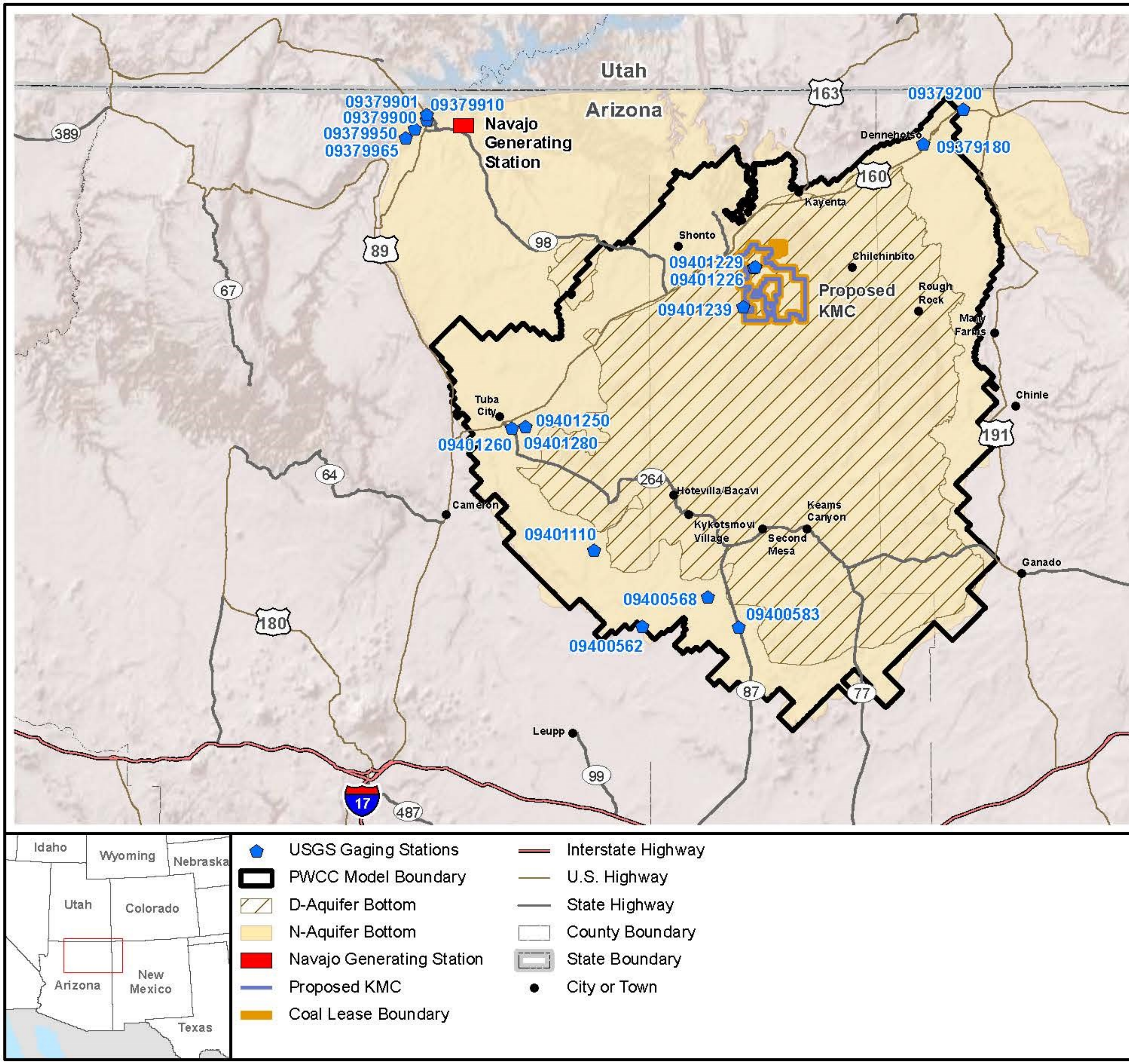


Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.4
D-Aquifer
2012 Water Levels

N

7/20/2016



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.5
Proposed KMC Aquifer Extents and USGS Stream Gages

X:\0Projects\SRP_NGS_KMC_60298037\FIGs\DOC\EIS\1_PDEIS\Letter_Sized\Water\FIG_WR_8_5_Aquifer_Extents.mxd

7/20/2016

The stream gages on Dinnebito Wash and Polacca Wash are located near the base of the D-Aquifer, suggesting that baseflow at these gages is at least partially from groundwater discharge from the D-Aquifer (GeoTrans 1999). Median winter flow is a surrogate for baseflow or groundwater discharge from the aquifer to the streams. For the period of record there have been no significant trends in baseflow at any of the stations (Macy and Unema 2014).

WR.8.11 Regional N-Aquifer Characteristics and Uses

The N-Aquifer is by far the major source of municipal and industrial groundwater in the Cumulative Study Area. Pumping withdrawals support the mining activities at the KMC, as well as municipal and industrial uses elsewhere in the CESA. These withdrawals are summarized below in the subsection about regional N-Aquifer use.

The average thickness of the N-Aquifer regionally is approximately 400 feet. In the coal leasehold, the top of the N-Aquifer is at depths ranging from approximately 2,300 to 2,600 feet below the ground surface. At other locations such as Tuba City or Kayenta, the aquifer is at the land surface. Over most of the mesa area, the N aquifer is effectively separated from the D-Aquifer by the Carmel Formation. PWCC drilling logs in the leasehold show that the top of the Carmel Formation there ranges from about 2,200 to 2,400 feet below the ground surface, and the formation is 140 to 170 feet thick.

Considerably beyond the leasehold, in the southern portion of Black Mesa where the Carmel Formation is thin or sandy, some downward leakage into the N-Aquifer occurs from the overlying Dakota/Cow Springs sandstones of the D-Aquifer (ADWR 1989; Lopes and Hoffman 1997; Truini and Longsworth 2003). Further information about the Carmel Formation and leakage through it is presented in **Appendix WR-6**. There is little or no downward leakage of groundwater from the N-Aquifer into the underlying C-Aquifer, because they are separated by approximately 1,000 feet of the relatively impermeable Chinle and Moenkopi Formations (ADWR 1989).

Total water stored by the N-Aquifer in the study area has been estimated at 166 million acre-feet (Eychaner 1983). Recharge to the N-Aquifer system generally occurs in the north-central part of the aquifer (Shonto area), north and west of Kayenta, where aquifer units are exposed at the land surface and precipitation is relatively high. Some recharge also occurs along the eastern boundary of the aquifer. Numerous studies of recharge to the N-Aquifer system have been made, with estimates ranging from 8,108 to 19,300 acre-feet/year (HDR 2003).

N-Aquifer groundwater flows to the northeast, where it discharges into Laguna Creek, to the northwest where it discharges into Navajo Creek, and to the southwest where it discharges into Moenkopi Wash. All three of these streams have perennial reaches of varying lengths supported by discharge from the N-Aquifer. The N-Aquifer also discharges to springs along the aquifer boundary (ADWR 1989). These perennial stream reaches and springs may potentially be affected by groundwater pumping from the N-Aquifer. Areas of groundwater discharge that have been modeled to assess potential impacts due to pumping include:

- Chinle Wash
- Laguna Creek
- Pasture Canyon
- Moenkopi Wash
- Dinnebito Wash
- Oraibi Wash
- Polacca Wash
- Jaidito Wash
- Begashibito Wash/ Cow Springs

N-Aquifer Parameters and Well Yields

Aquifer specific yield estimated from laboratory core samples ranged from 18 to 29 percent for the Navajo Sandstone (Cooley et al. 1969). In the confined portion of the N-Aquifer the calibrated specific storage coefficient used in the PWCC groundwater flow model is 3×10^{-7}. Based on specific capacity data from 86 wells reportedly screened in one or more N-Aquifer units, hydraulic conductivity ranges from 0.01 to 17 feet/day (HDR 2004). Higher values appear to be associated with the unconfined portion of the aquifer, perhaps due to stress release and subsequent fracturing of the sandstone. **Table WR-8.24** below summarizes the horizontal hydraulic conductivity values by area.

Table WR-8.24 N-Aquifer Hydraulic Conductivity

Parameter	Confined N-Aquifer	Unconfined N-Aquifer
No. of Tests	33	52
Average	0.42	1.17
Median	0.18	0.37
Minimum	0.01	0.01
Maximum	2.07	16.95

These values are indicative of the relatively low permeability nature of the formations comprising the N-Aquifer system but are somewhat higher, especially in the unconfined potions of the aquifer, than the D-Aquifer.

N-Aquifer well yields vary from a few gallons per minute (gpm) at windmills to over 600 gpm at the PWCC wells. Due to the relatively low permeability of the N-Aquifer sandstone units, water level drawdown in most wells is large. **Table WR-8.25** summarizes statistics on well yields, drawdown and specific capacity for N-Aquifer wells in the study area.

Table WR-8.25 N-Aquifer Well Yield, Drawdown and Specific Capacity

Parameter	Values (gpm)	Drawdown (feet)	Specific Capacity (gpm/foot)
No. of Wells	118	108	108
Average	71	104	1.19
Median	30	46	0.83
Minimum	3	4	0.02
Maximum	632	518	7.95

USGS Water Level Monitoring

The USGS has been monitoring N-Aquifer water levels since 1981 and currently uses a groundwater-monitoring network of 34 wells to track annual water-level changes. Specifically, six non-pumping observation wells, identified as USGS BM1 through BM6, are used to evaluate the regional hydrologic condition of the N aquifer. USGS wells BM-1 through BM6 have been monitored since the 1970s and are currently equipped with continuous recording devices, collecting a water-level measurement every 15 minutes. BM6 has the largest measured regional drawdown compared to pre-pumping conditions in 1965. In BM6 the depth to groundwater had increased by 155 feet in 2004 (USGS 1985-2005). The USGS groundwater monitoring also indicates that although drawdown has occurred in the N-Aquifer, measured water levels have not dropped below the top of the aquifer within the confined basin. As the aquifer remains confined, groundwater in wells will continue to be above the top of the aquifer.

Therefore, the saturated thickness (thickness of aquifer containing groundwater) of the confined N-Aquifer is unchanged at the monitored locations.

The USGS also measures non-pumping (static) water levels on an annual basis in selected N-Aquifer water supply wells. In 2012 water levels were measured in 34 wells. Depth-to-water varied from 28.2 (Tuba City) to 1,335.6 feet bgs (Kitsillie NTUA 2). Change in water levels from 2011 to 2012, and from pre-1965 to 2012, are given in **Table WR-8.26** (Macy and Unema 2014).

Table WR-8.26 N-Aquifer Median Water Level Change

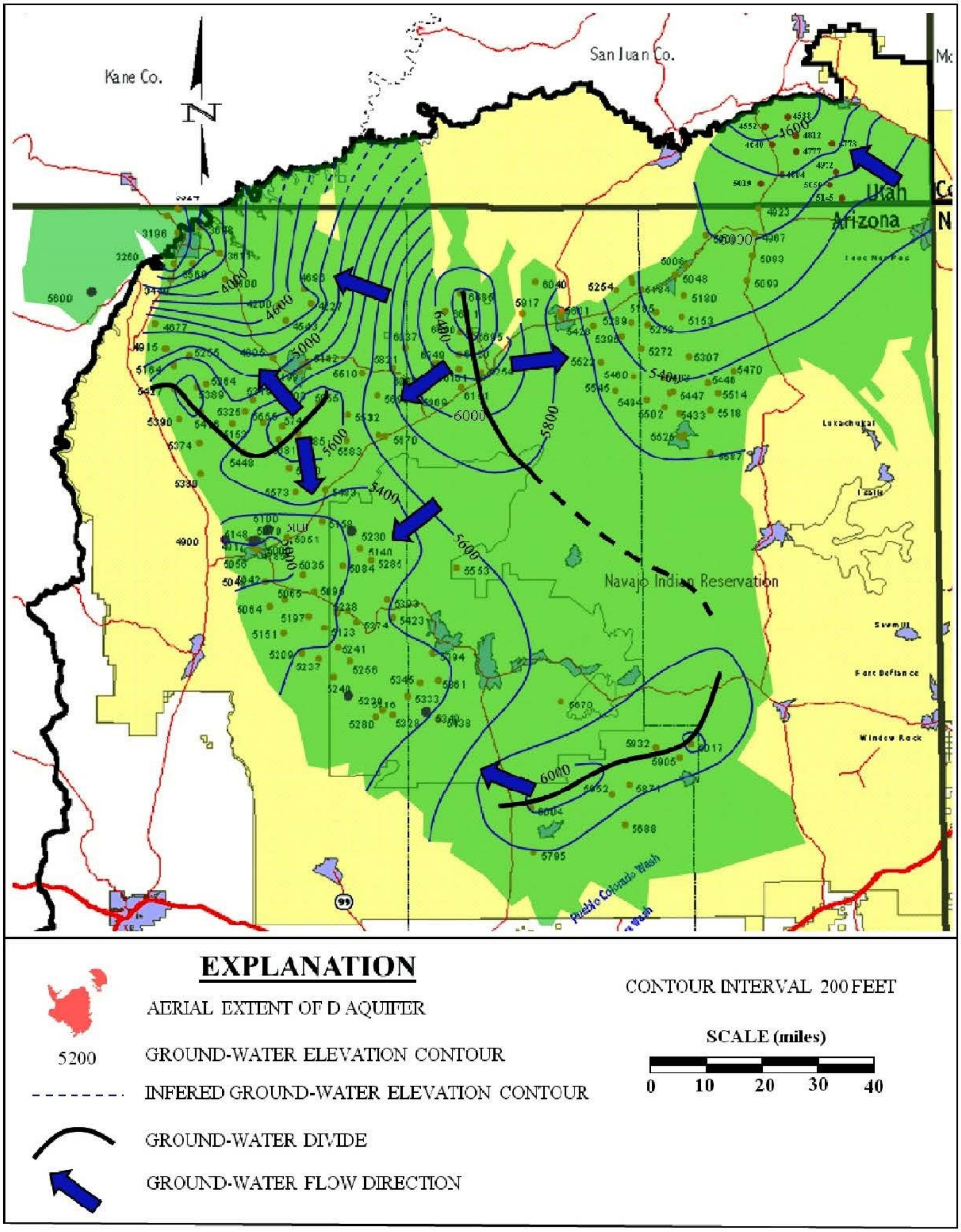
Years	Aquifer Conditions	Number of Wells	Median Change (feet)
2011-2012	All	33	-0.1
	Unconfined	15	-0.1
	Confined	18	0.0
Pre-Stress - 2012	All	34	-13.4
	Unconfined	16	-2.1
	Confined	18	-39.1

Figure WR-8.6 shows the pre-development water level contours and direction of groundwater movement. Model simulated 2012 water levels and water movement are shown on **Figure WR-8.7**. Water levels in most of the unconfined areas of the aquifer have changed only slightly (generally less than 10 feet) over time. Water levels in the confined area have declined over time, with the greatest declines occurring near municipal pumping centers and in the PWCC well field. Continuous water level measurements have been recorded at the six Black Mesa (BM) Observation Wells. The two wells located in the unconfined N-Aquifer (BM1 and BM4) have shown small seasonal variations but no long-term decline. Wells in the confined area have consistently declined since the early 1970s through 2007. In 2007, BM6 showed a distinct change and started to rise, recovering by about 14 feet in 2012. Since 2009, BM2 the water level has flattened out (Macy and Unema 2014). Locations of the PWCC and BM wells are shown on **Figure WR-8.8**. BM2 and BM6 are closest to the PWCC well field; the change in water level since 2007 in these wells is thought to be due to decreased pumping from the PWCC well field starting in 2006.

Additional figures that indicate N-Aquifer water levels over time are included as **Figures WR.8-9** through **WR.8-12**. Based on data available along selected lines of section on and near Black Mesa, these figures depict the N-Aquifer water levels at wells from the 1970s through recent times. **Figure WR.8-9** shows the three lines of section across the Black Mesa area. **Figures WR.8-10** through **WR.8-12** depict the historic water levels along cross-sections A, B, and C, respectively.

On cross-section A-A', combined community and mine-related pumping has created drawdown at or near the top of the N-Aquifer by the towns of Kayenta and Rough Rock. These two locations are at the edge of the confined/unconfined transition. Elsewhere over the section, N-Aquifer water levels in wells are above the aquifer itself. Recovery since 2010 has occurred at Well 8T-500 near Kayenta and at all the other wells along the cross-section.

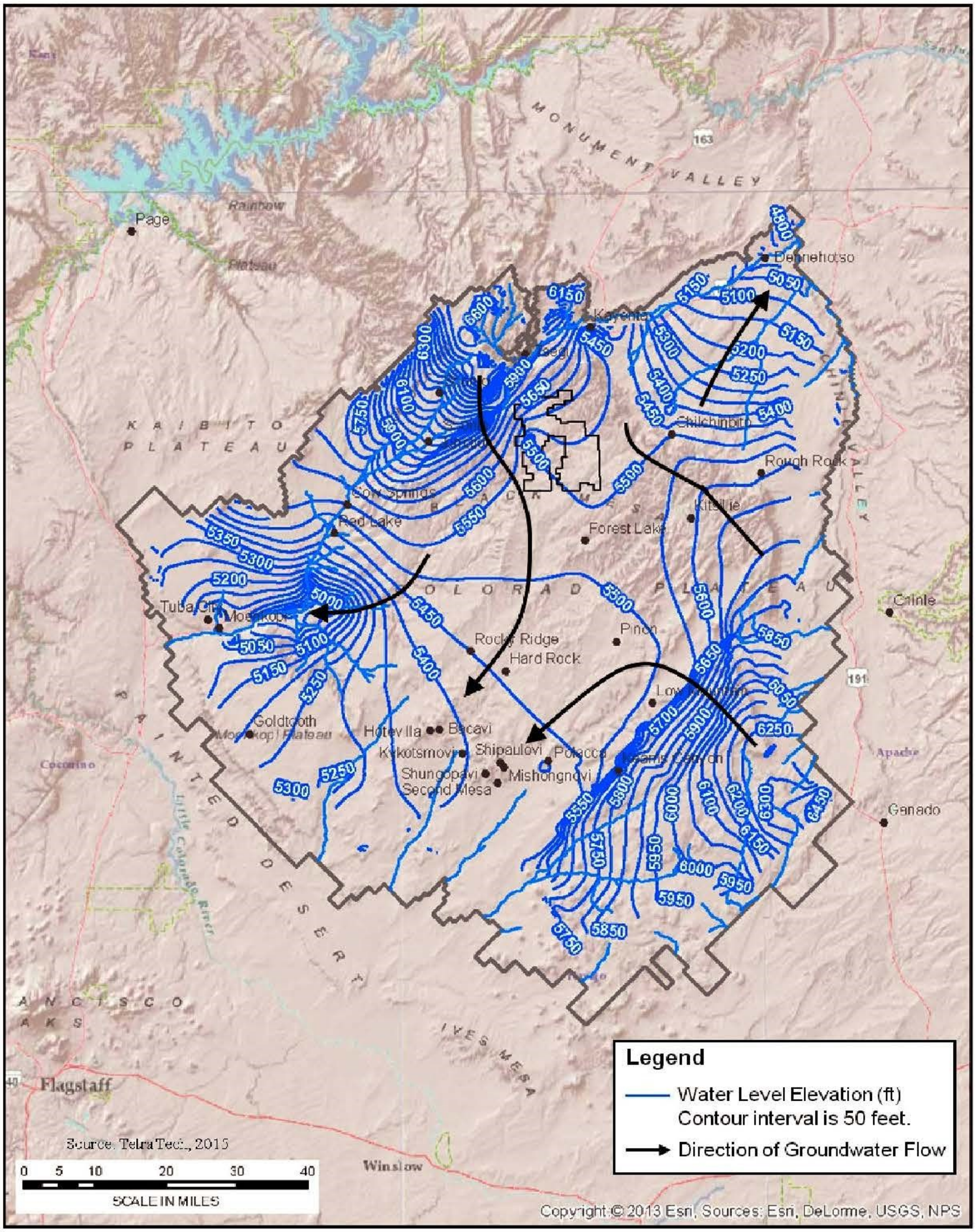
X:\0Projects\SRP_NGS_KMC_60299037\FIGs\DOCEIS\1_PDEIS\Letter_Sized\Water\FIG_WR_8_6_N-AquiferPre1966WaterLevels.mxd



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.6
N-Aquifer
Pre-1966 Water Levels

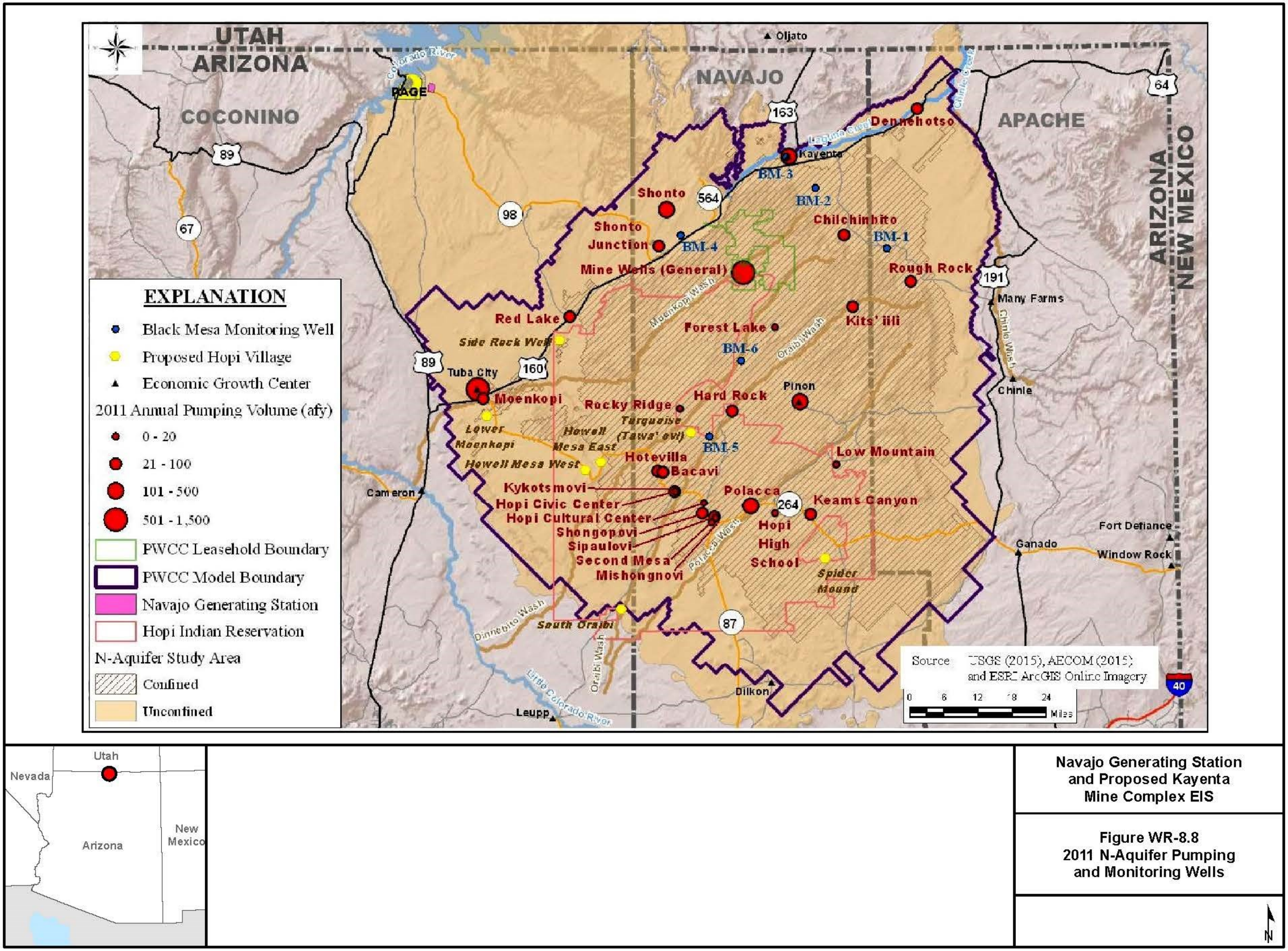
7/20/2016



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.7
N-Aquifer
2012 Water Levels

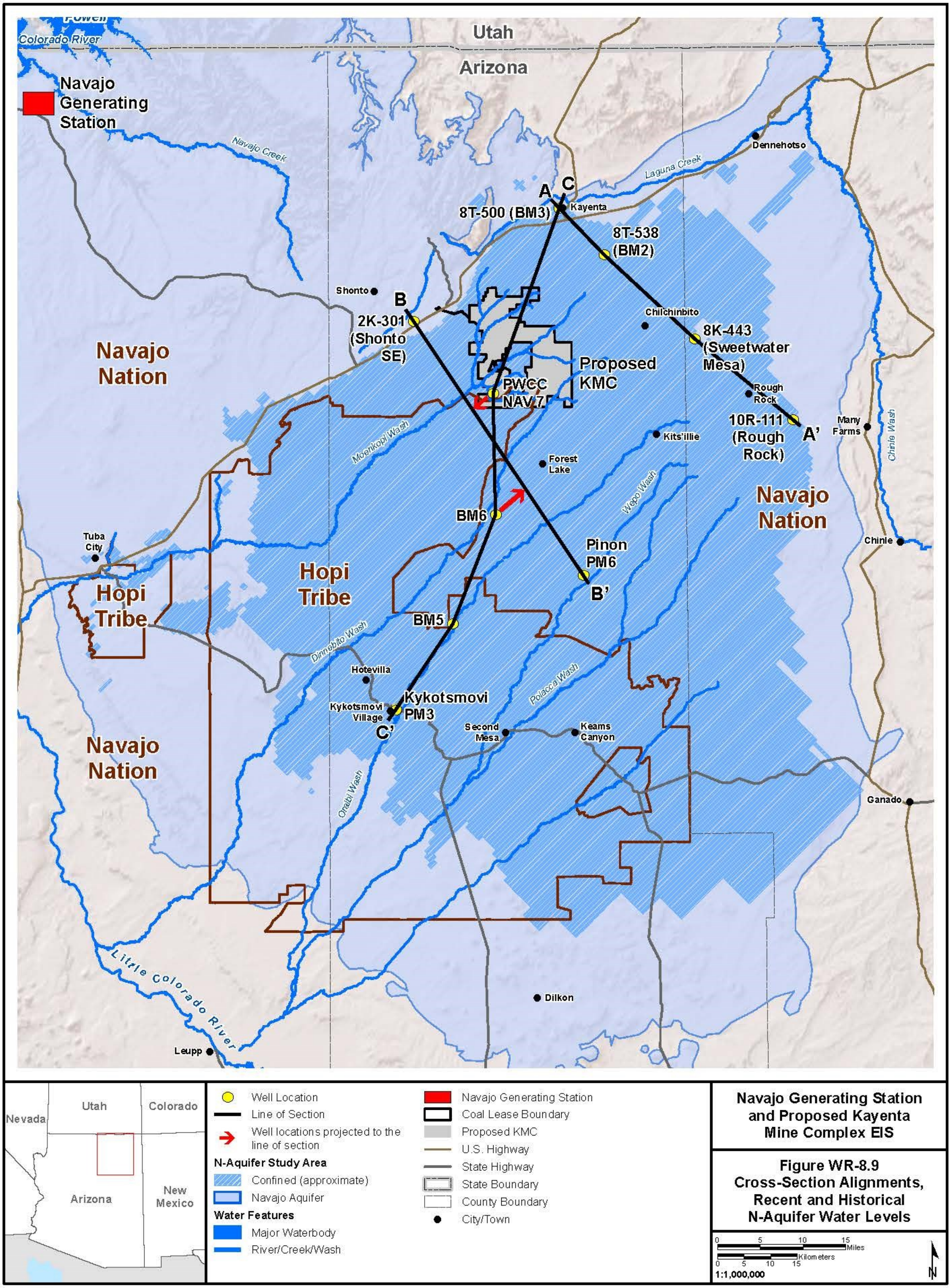
7/20/2016



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.8
2011 N-Aquifer Pumping and Monitoring Wells

7/20/2016

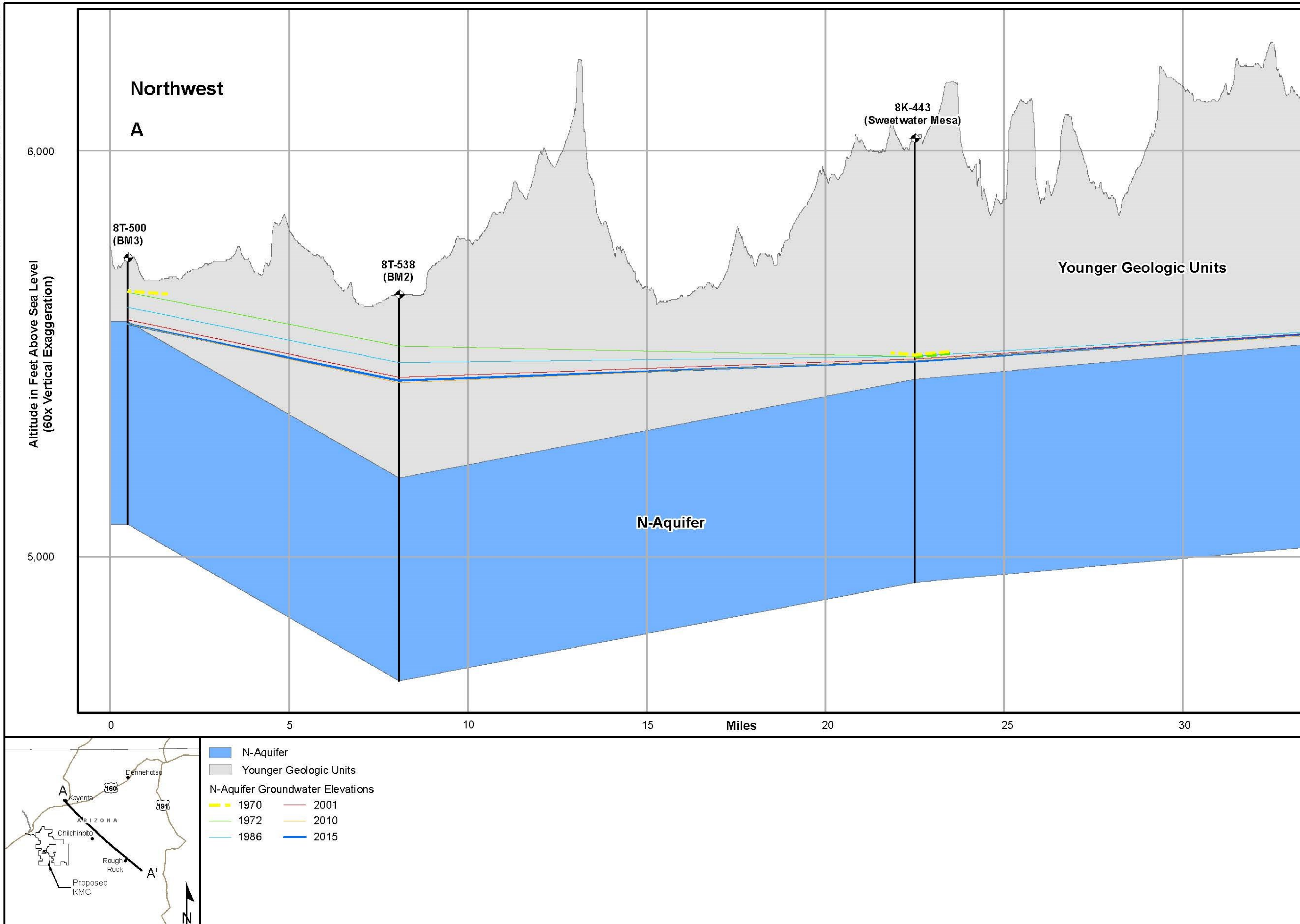


Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.9
Cross-Section Alignments, Recent and Historical N-Aquifer Water Levels

8/9/2016

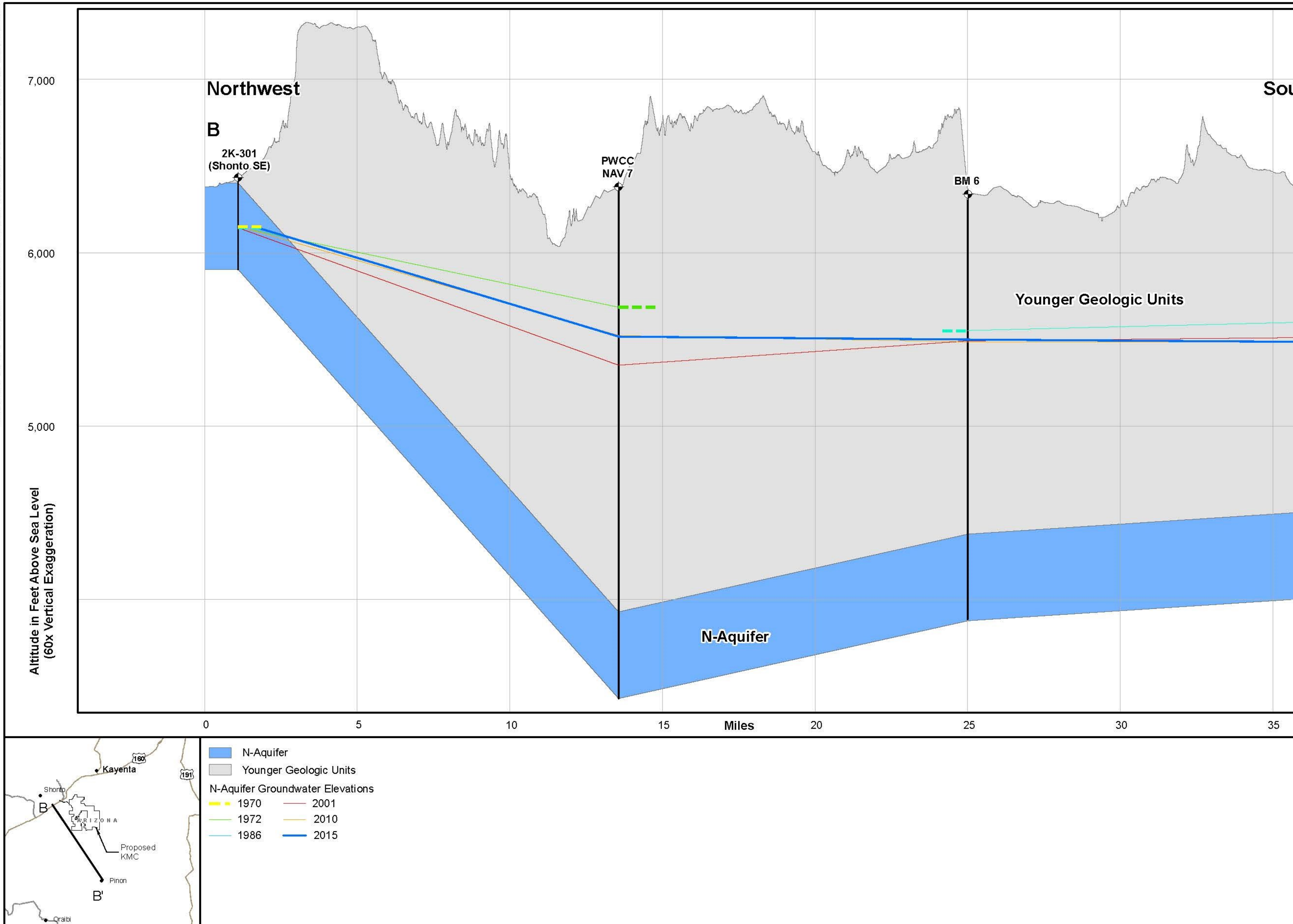
This page intentionally left blank



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.10
Recent and Historical N-Aquifer Water Levels - Cross Section A-A'

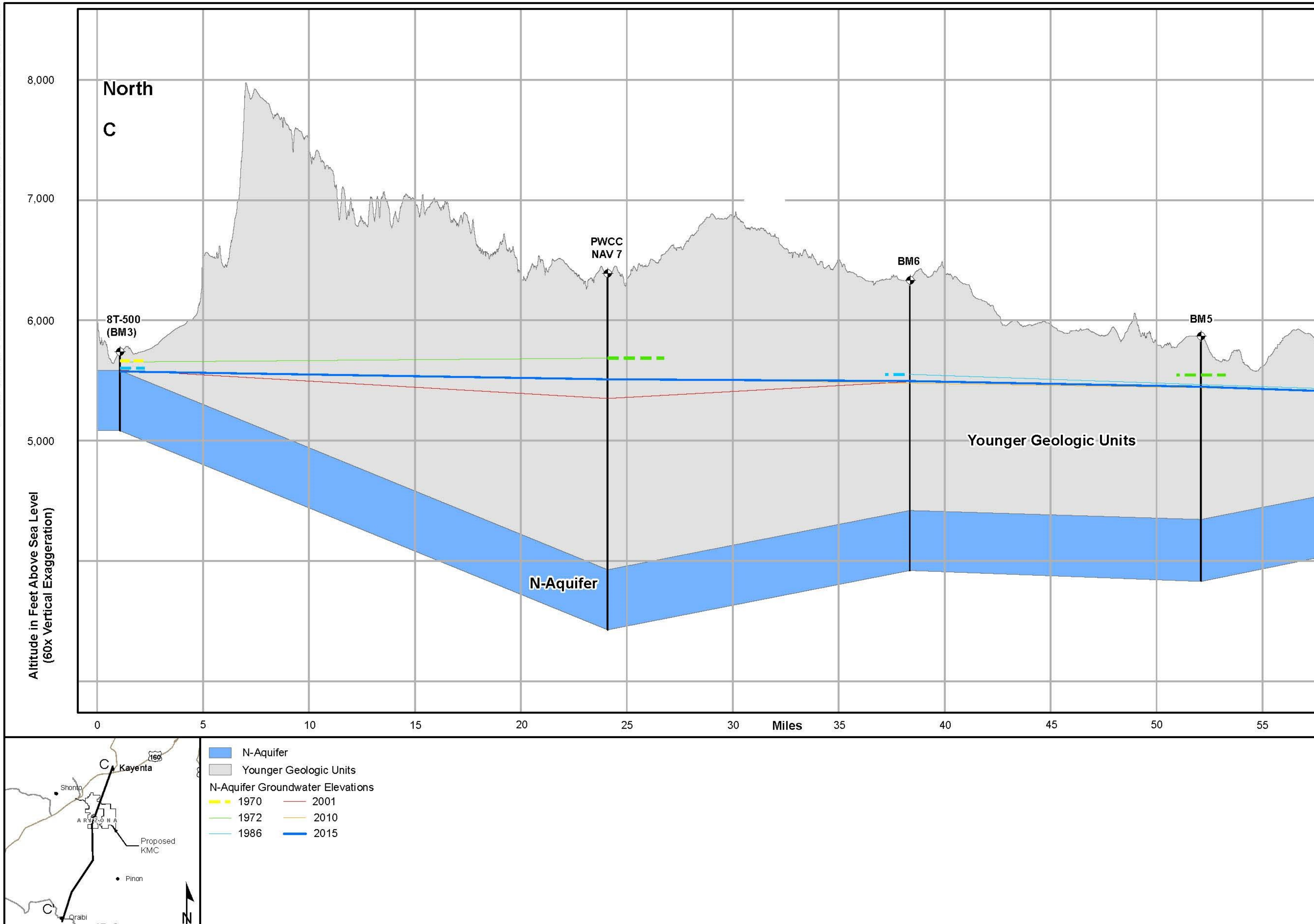
X:\Projects\SRP_NGS_KMC_60290037\FIGs\DOEIS\1_PDEIS\11X17_WaterFigures\FIG_WR_8_11_XS_B_VE30.mxd



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.11
Recent and Historical N-Aquifer Water Levels - Cross Section B-B'

8/9/2016



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.12
Recent and Historical N-Aquifer Water Levels - Cross Section C-C'

8/9/2016

This page intentionally left blank

On cross-section B-B’, drawdown from pumping and groundwater discharges to stream baseflows, springs, and evapotranspiration create water levels within the aquifer itself at Well 2K-301 near Shonto. These conditions reflect the unconfined nature of the N-Aquifer at that location. Along the rest of section B-B’, water levels in wells are far above the aquifer itself. This includes wells within the PWCC leasehold, at Forest Lake, and at Pinon. Substantial recovery since 2001 can be seen at PWCC NAV7, at Shonto (2K-301), and at BM6. At Pinon PM6, recent water levels are similar to the 2001 values or somewhat lower.

On cross-section C-C’, the north-south line indicates similar conditions near Kayenta as described previously for cross-section A-A’. Recovery has occurred since 2010 near Kayenta and at PWCC NAV7 on the coal leasehold. To the south, water levels in wells have risen recently at BM6, but have been fairly similar since 2001 at BM5 and Kykotsmovi PM3.

PWCC was the dominant user of water pumped from the confined N-Aquifer during the period 1970 through 2005 (OSMRE 2012). Water level changes in some N-Aquifer wells monitored by the USGS on Black Mesa are indicated below in **Table WR-8.27**. These reflect the difference between at least one historical measurement in the pre-stress (pre-pumping) period compared to 2012 water levels. Results reflect both project pumping and community pumping.

Table WR-8.27 Change in Selected Black Mesa N-Aquifer Water Levels, feet, between Measurements During the Pre-Stress Period and 2012

USGS Observation Site	Location	Change in Water Level (feet)
BM6	Along Dinnebito Wash, about 12 miles south of the coal lease boundary	-151.0
Forest Lake NTUA 1	About 8 miles south of the southeastern part of the coal leases	-77.8
Kitsillie NTUA	About 10 miles southeast of the southeast corner of the coal lease boundary	-37.7
BM5	Along Oraibi Wash about 27 miles south-southwest of the coal lease boundary, about 12 miles northeast of Kykotsmovi	-103.2

Source: Macy and Unema 2014.

At USGS observation well BM6, water levels declined from about the 800-foot depth bgs in January 2004, to a maximum depth of 861.2 feet bgs in early December 2006. This represented a decline of about 164.2 feet from the pre-stress water level of 697.0 feet bgs (OSMRE 2012). Pumping during most of this period reflected mine supplies, plus withdrawals to pipe coal slurry to the Mojave Power Plant. The coal slurry operations ended at the end of 2005, and there was about a 1-year lag in N-Aquifer recovery until December 2006. As of early August 2012, the aquifer had recovered 13.9 feet, to a water level of 847.3 feet bgs. This represents an 8.5 percent recovery from the lowest level in December 2006 (OSMRE 2012). Water level declines continued at BM5, more distant from the KMC, but slowed substantially to a nearly flat rate in the fall of 2011. In April 2004, the water level in BM5 was about 413 feet bgs. It reached 437.2 feet bgs in 2012 (Macy and Unema 2014). Well BM5 is within 15 miles of several Hopi municipal pumping locations, and some Navajo Nation locations. In 2010, 732.4 acre-feet were pumped from the confined N-aquifer within 15 miles of BM-5 (OSMRE 2012).

Regional N-Aquifer Water Quality

Groundwater from the N-Aquifer is considered to be of good to excellent quality and is suitable for most uses. Generally the groundwater contains less than 500 mg/L of TDS and rarely exceeds 1,000 mg/L.

A number of other N-Aquifer wells have been sampled elsewhere on Black Mesa by the USGS. Results for three of these are summarized in **Table WR-8.28** below.

Table WR-8.28 Summary of Other Navajo-Aquifer Well Water Quality on Black Mesa

USGS Well Number	Location	TDS Average (Minimum / Maximum), mg/L	Sulfate Average (Minimum / Maximum), mg/L	Arsenic Average (Minimum / Maximum), µg/L [1]	Fluoride Average (Minimum / Maximum), mg/L [1]	Lead Average (Minimum / Maximum), µg/L [1]	Selenium Average (Minimum / Maximum), µg/L [1]
361737 110180301	Forest Lake	372 (183 / 914)	92.8 (24 / 384)	2.4 (1.0 / 3.3)	0.68 (0.10 / 1.7)	Not detected in 2 analyses	Not detected in 2 analyses
362043 110030501	Kitsillie	272 (264 / 278)	4.4 (3.7 / 4.9)	4.0 (3.7 / 4.1)	0.47 (0.18 / 1.6)	No Data	No Data
362035 110032201	Unnamed	502 (232 / 1,020)	197 (4.9 / 520)	25.8 (4.0 / 39)	0.39 (0.20 / 0.70)	Not detected in 2 analyses	Not detected in 2 analyses

[1] Dissolved

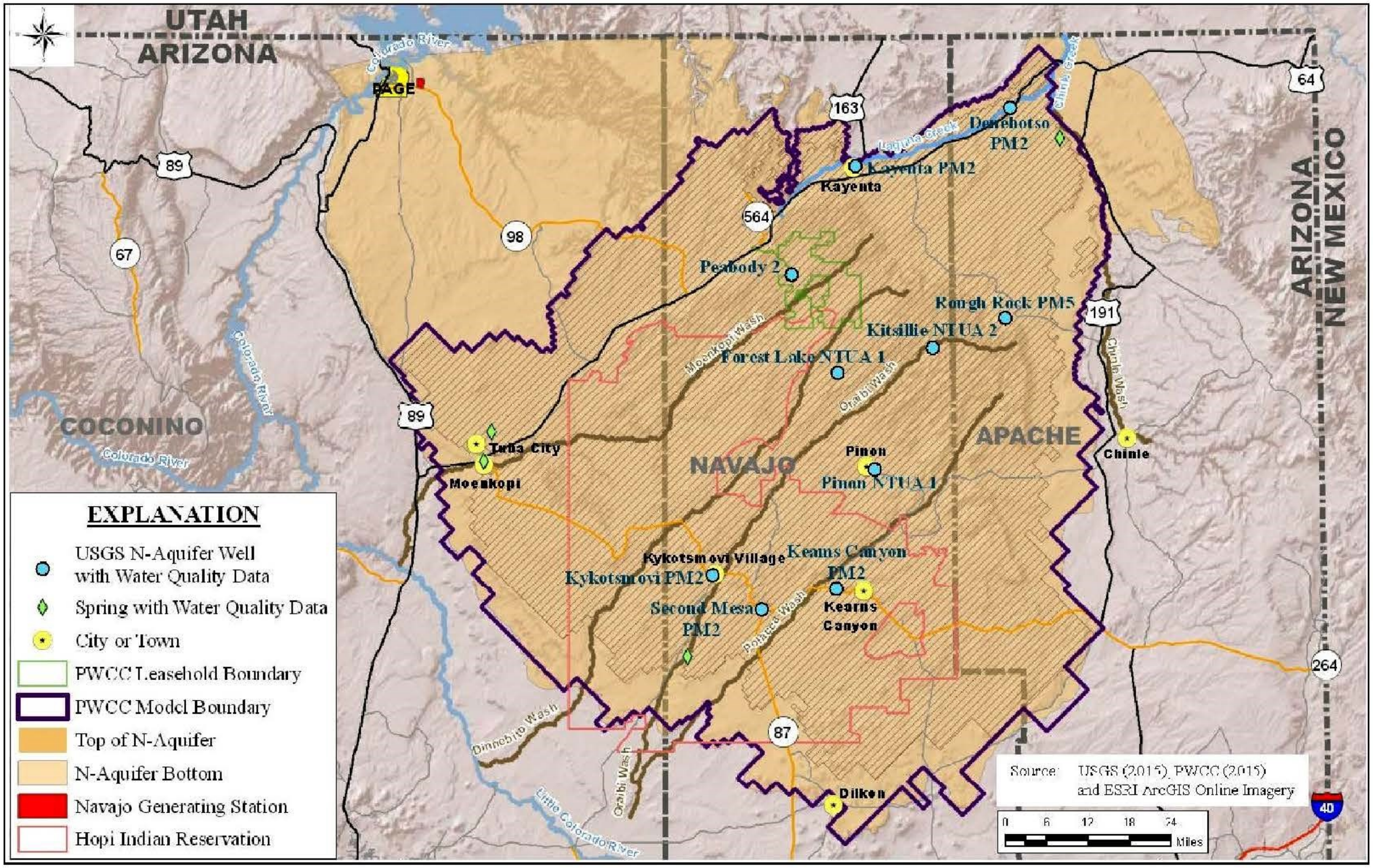
Source: USGS-NWIS 2016.

Elsewhere in the cumulative study area, water quality is monitored by the USGS on an annual basis at selected regional community wells and springs. Ten wells and four springs were sampled in 2012 at the locations shown on **Figure WR-8.13**. Selected 2012 water quality parameters are presented below in **Table WR-8.29**.

Table WR-8.29 Regional N-Aquifer Water Quality

Well	pH (units)	Nitrogen, $NO_2 + NO_3$	Calcium	Magnesium	Sodium	Chloride	Flouride	Sulfate	Arsenic	Boron	Iron	Total Dissolved Solids
		(mg/L)										
Second Mesa PM2	8.7	<0.040	0.500	0.034	131.0	7.26	0.32	14.90	**0.0177**	0.093	0.0043	346
Keams Canyon PM2	8.8	<0.040	0.860	0.168	217.0	102.00	1.41	35.20	**0.0424**	0.642	0.0138	**608**
Kykotsmovi PM2	9.3	1.130	0.494	0.014	76.0	3.07	0.18	7.75	0.0053	0.031	<0.0032	219
Pinon NTUA 1	9.8	1.260	1.090	0.155	146.0	7.09	0.26	64.30	0.0046	0.074	<0.0032	407
Forest Lake NTUA 1	9.4	0.568	0.823	0.080	78.3	11.30	0.35	36.00	0.0032	0.090	0.0138	219
Kitsillie NTUA 2	9.7	1.370	0.518	0.014	96.3	3.77	0.18	4.94	0.004	0.045	<0.0032	270
Rough Rock PM5	8.7	1.040	2.080	0.296	232.0	130.00	1.86	116.00	**0.0498**	0.415	0.0114	**649**
Peabody 2	8.7	0.956	8.690	0.137	27.6	2.04	0.13	7.25	0.0029	0.016	<0.0032	122
Kayenta PM2	7.5	0.839	44.000	7.110	23.4	3.71	0.20	62.50	0.0023	0.028	<0.0032	222
Denehotso PM2	8.7	1.410	7.130	1.900	57.6	7.59	0.29	13.60	0.0062	0.043	<0.0032	184
Spring												
Burro Spring	7.2	<0.040	58.600	4.370	61.9	23.10	0.35	64.70	0.001	0.001	0.02	330
Moenkopi School Sp	6.6	2.010	35.100	7.580	29.1	27.50	0.15	33.30	0.002	0.004	0.004	218
Pasture Canyon Spri	8.0	4.330	29.800	4.480	12.2	5.20	0.14	17.50	0.002	0.000	<0.0032	142
Unamed Spring Nea	7.8	1.730	33.900	5.720	14.9	13.50	0.64	21.90	0.002	0.000	0.01	179

Bold - exceeds MCL or SMCL for drinking water



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.13
N-Aquifer
Water Quality Wells

The N-Aquifer generally produces high quality water that meets drinking water standards. However, three (3) of the sampled wells have arsenic concentrations above the MCL for drinking water. These wells also have elevated sulfate and total dissolved solid concentrations and are in an area that is thought to be experiencing downward leakage from the D-Aquifer, either through natural pathways or through poor well construction (Truini and Macy 2006). There are plans underway (Hopi Arsenic Mitigation Project) to provide water from new N-Aquifer wells located outside the area of downward leakage to several Hopi Villages that are currently receiving water from wells with elevated arsenic concentrations (IHS 2014).

Regional N-Aquifer Water Use

The N-Aquifer supplies the majority of the water for the mining operations at the Kayenta Mine Complex. It also is used extensively by the Hopi and Navajo tribes as a public drinking water supply. N-Aquifer water withdrawals in 2011 are estimated to total approximately 4,523 acre-feet. **Figure WR-8.8** previously showed the distribution and magnitude of 2011 N-Aquifer municipal and industrial withdrawals. In addition, there are approximately 235 windmill powered wells that supply water for livestock. Withdrawal from these wells is not measured, but is estimated to total on the order of 55 acre-feet/yr (Tetra Tech 2015).

Total withdrawals from the N aquifer increased from about 70 to 8,000 acre-feet/year from 1965 to 2002, with the major increase due to industrial use by the wells for PWCC operations. PWCC operations greatly decreased their use of the N-Aquifer at the end of 2005, when the coal slurry pipeline to the Mojave Power Plant ceased operations. Municipal use in 2011 totaled approximately 3,057 acre-feet/year, with 1,451 acre-feet/year attributable to wells in the confined area and 1,606 acre-feet/year to wells in the unconfined area. **Table WR-8.30** below lists the 2011 withdrawals by community.

Table WR-8.30 N-Aquifer 2011 Community Withdrawals

Community	Withdrawal (acre-feet)
Kayenta	441
Shonto	166
Dennehotso	60
Chilchinbito	64
Rough Rock	61
Forest Lake	15
Pinon	337
Hard Rock	50
Shonto Junction	93
Red Lake	59
Rocky Ridge	6
Moenkopi	87
Tuba City	1,162
Hotevilla	25
Bacavi	24
Low Mountain	0
Hopi High School	17
Keams Canyon	59
Mishonghovi	5

Table WR-8.30 N-Aquifer 2011 Community Withdrawals

Community	Withdrawal (acre-feet)
Second Mesa	7
Kykostmovi	67
Hopi Civic Center	2
Hopi Cultural Center	7
Shungopovi	38
Shipaulvi	20
Polacca	185
Total	**3,057**

Since 1990, total N-Aquifer usage at these 26 communities or pumping centers within the CESA ranged from about 1,700 to 3,370 acre-feet per year. More recent combined withdrawals ranged from about 2,530 to 3,120 acre-feet per year for these non-project centers during the period 2007 through 2012. These are monitored withdrawals; additional N-Aquifer withdrawals were likely from windmills or smaller outlying villages and pumping centers as mentioned above. Community usage is anticipated to increase in response to population growth and increased per capita use, as discussed in under cumulative impacts in the Socio-Economic assessment. The general conditions of N-Aquifer pumping over time are depicted in **Figure WR-8.14**. Based on observed data, the figure depicts the reduction in mine-related pumping in the Year 2005, and the relative portions of mine-related and community pumping observed from the N-Aquifer before and after Year 2005.

N-Aquifer Discharge to Springs and Streams

Groundwater from the N-Aquifer discharges to springs around the margin of Black Mesa where the aquifer changes from confined to unconfined conditions. Many of these springs are small, not readily accessible and have no discharge measurements. The USGS recently undertook a study to identify and characterize springs identified by various sources. Sixty-eight (68) springs characterized as “likely” based on analysis of imagery and aerial photography were identified as emanating from N-Aquifer stratigraphic units. With the exception of the four USGS monitored springs discussed below, individual sites were not visited and no flow data are available. However, subsequent to the USGS inventory efforts, some sites were visited during an inter-agency project field trip in early April 2016. That trip was made to both N-Aquifer and D-Aquifer spring and seep sites as part of field verifications for the water resources monitoring program. Due to the sacred nature of some springs to the Navajo and Hopi people, the locations of the non-monitored springs are not published. They will, however, be included in the assessment of potential impacts due to projected groundwater withdrawals.

The USGS has been monitoring the discharge from four springs since as early as 1952. These springs and their 2012 measured flow rates are given in **Table WR-8.31** below.

Table WR-8.31 Selected 2012 Spring Discharges

Spring	Discharge (gpm)
Moenkopi School	6.3
Burro	0.3
Pasture Canyon	26.5
Unnamed Spring near Dennehotso	4.5

The Moenkopi School spring (also known as Susunova Spring) is located in the western part of the groundwater study area. This spring experienced a decrease in flow from 2011 to 2012 of 30 percent (about 2.7 gpm). Based on linear regression, over the period of record, spring discharge has declined an average of about 0.3 gallons per year (Macy and Unema 2014).

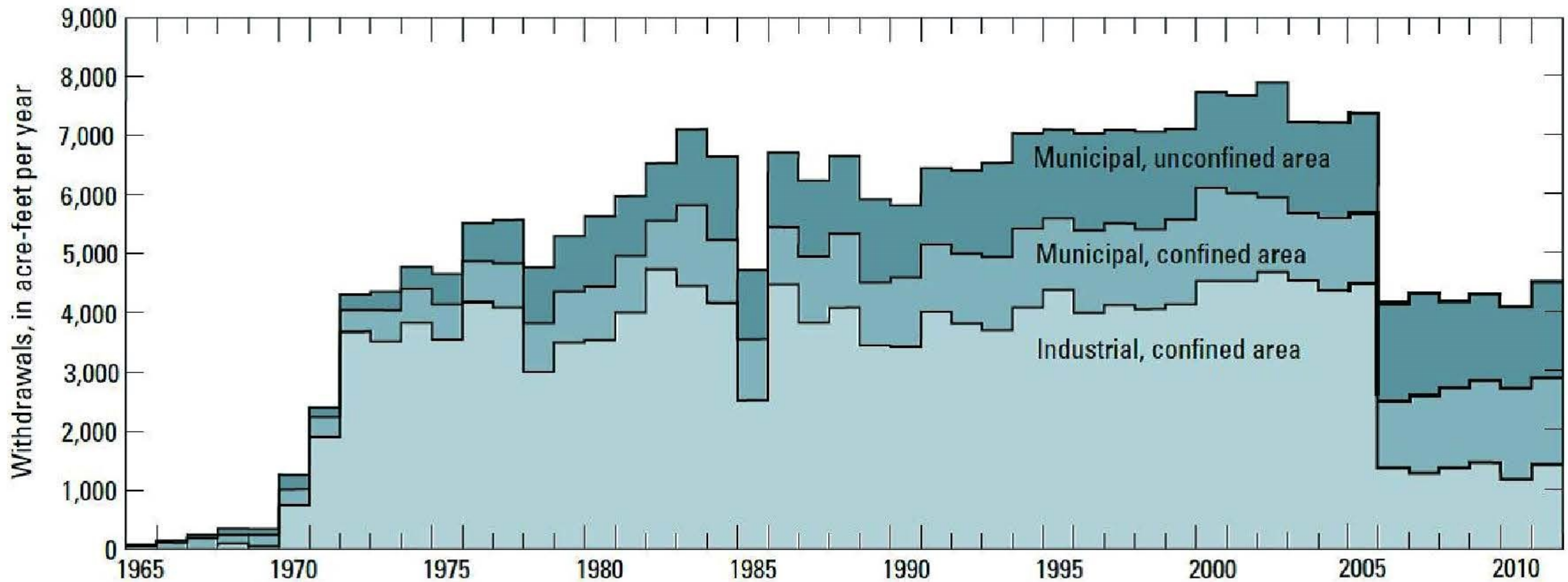
Burro Spring is in the southwestern portion of the groundwater study area. From 2011 to 2012 discharge declined about 25 percent (about 0.1 gpm). Since 1989 discharge has varied from 0.2 and 0.4 gpm, but there is no significant trend in the data (Macy and Unema 2014).

Pasture Canyon Spring is located near Tuba City in the western portion of the study area. Between 2011 and 2012 discharge decreased by about 5 gpm, or 16 percent. The long-term record for this spring shows a decreasing trend (Macy and Unema 2014).

The Unnamed Spring near Dennehotso is located in the northeastern part of the groundwater study area. There has been a marked decrease in flow from this spring since 2005. However, over the period of record (1954-present) there is no appreciable trend in the data (Macy and Unema 2014).

As noted in the subsection above about the D-Aquifer, the USGS has been operating four streamflow gages on Black Mesa (**Table WR-8.22, Figure WR-8.5**). Two of these stream gages, Moenkopi Wash (09401260) and Pasture Canyon Spring (09401262) appear to monitor groundwater discharge from the N-Aquifer. Over the period of record there have been no significant trends in median winter flows at these gages (Macy and Unema 2014).

X:\0Projects\SRP_NGS_KMC_60298037\FIGs\DOC\EIS\1_PDEIS\Letter_Sized\Water\FIG_WR_8_14_NAquiferWithdrawalsBMarea.mxd



Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-8.14
N-Aquifer Withdrawls,
Black Mesa Area,
Northeastern Arizona, 1965-2011

N

7/20/2016

This page intentionally left blank

Appendix WR-9

Groundwater Flow Modeling of the D- and N-Aquifers

This page intentionally left blank

APPENDIX WR 9

GROUNDWATER FLOW MODELING OF THE D-AND N-AQUIFERS

INTRODUCTION

For the NGS-KMC EIS, the major impacts to the D- and N-Aquifer hydrologic system are associated with groundwater pumping for Peabody Western Coal Company's (PWCC) Kayenta Mine Complex (KMC) and for Navajo and Hopi Community water supply needs. Groundwater is also withdrawn by windmills, primarily for livestock use, however these uses account for less than one (1) percent of the total use. Reported Community withdrawals totaled 70 acre-feet per year (ac-ft/yr) in 1970 (Macy and Unema 2014). PWCC started pumping from eight (8) industrial wells in 1965. By 1972 PWCC withdrawals increased to 3,682 ac-ft/yr and continued at an average annual rate of 3,983 ac-ft through 2005. On January 1, 2006 the annual PWCC withdrawals were reduced to approximately 1,400 ac-ft in response to closure of the Black Mesa Mine and coal slurry pipeline (OSMRE 2011). By 2011 Community pumping had increased to approximately 3,090 ac-ft/yr, while PWCC pumping remained at 1,390 ac-ft. Future projected pumping by PWCC for the KMC is given in **Table WR-9.1**.

Table WR-9.1, PWCC Future Withdrawals

Time Period	Annual Withdrawal (ac-ft)
2019-2044	1,200
2045-2047	500
2048-2057	100

By the year 2057 PWCC pumping is scheduled to cease. Community pumping will continue indefinitely. The rate of future Community withdrawals is uncertain, but was estimated to assess cumulative impacts on the N-Aquifer hydrologic system. The estimated total N-Aquifer annual community and windmill withdrawal by 2110 to be modeled is approximately 17,600 ac-ft (Tetra Tech 2015).

While KMC pumping is scheduled to end in 2057, water level declines due to PWCC withdrawals will not cease immediately. Water levels in the PWCC water supply wells will start to recover quickly; however, at more distant points water levels will continue to decline in response to past pumping. *Maximum mine-related project impact at any given point (well, spring, stream) will occur when the water level drawdown due to PWCC pumping is at its maximum.* Water level declines due to Community pumping will continue at an increasing rate over time due to projected compounding growth in water demand. To assess these future changes it is necessary to employ a groundwater flow model of the D- and N-Aquifers on Black Mesa.

EXISTING GROUNDWATER FLOW MODELS

Several groundwater flow models of the Black Mesa area have been developed, the most recent of which include:

- USGS 2D N-Aquifer model (Eychaner 1983) and subsequent refinements (Brown and Eychaner 1988, Thomas 2002),
- HSI/GeoTrans 3D, D- and N- Aquifer model (1999) with 2005 and 2014 updates (HSI/Geotrans and Waterstone 1999, Geotrans 2005, Tetra Tech 2014), and
- HDR WNH N-Aquifer model (HDR 2003).

The U. S. Bureau of Reclamation (USBR) retained the U.S. Geological Survey (USGS) to conduct a peer review these models and assess their applicability to the analysis required to support the NGS-KMC EIS. During the USGS review, the HDR WNH N-Aquifer model was found to have some structural issues with its layering and could not be successfully run and evaluated. However, model construction and outputs are documented (HDR 2003a,b,c.) and were used by the USGS in their review included in the USGS Administrative Report in support of the EIS.

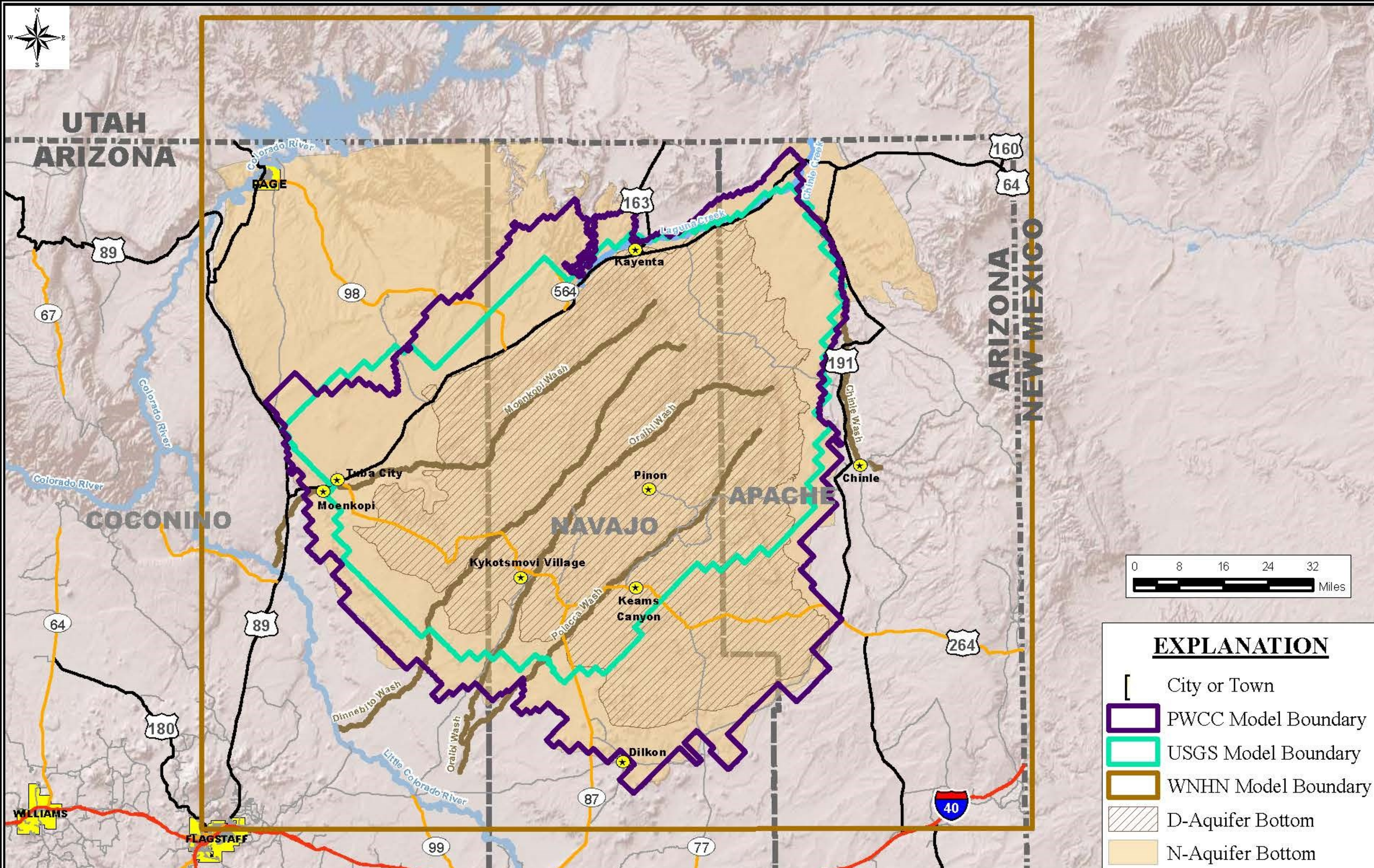
USGS MODEL REVIEW

The USGS Black Mesa Model (Brown and Eychaner 1988) was developed to assess the changes in groundwater levels and flow components due to projected withdrawal alternatives for both PWCC mine activities and community pumping. It is a one-layer (2-D) model using an earlier version of MODFLOW and has been converted to run on MODFLOW 2000 and 2005 (Leake et al. 2016; Thomas 2002).

The PWCC Groundwater Flow Model was developed in 1999 by Waterstone and HSI GeoTrans (now Tetra Tech, Inc.) for PWCC to support the company's permit applications and predict the impact of PWCC's past and future pumping on water levels in the D and N-Aquifers in the Black Mesa area. The model is a 3-D model that simulates the D- and N-Aquifers and flow between them. While the model includes industrial (PWCC), windmill and municipal pumping the focus is on the effects of PWCC pumping. The PWCC model has been updated several times and was comprehensively updated in January 2014 (Tetra Tech 2014).

The WNH N-Aquifer 3-D Groundwater Flow Model was developed in 2003 to support the Western Navajo and Hopi Water Supply Needs, Alternatives, and Impacts Study. This USBR study focused on the development and analysis of water supply alternatives to meet the future water supply needs of the Western Navajo and Hopi reservations. The WNHN-Aquifer model was developed to address concerns about potential impacts on springs, particularly springs that were outside the PWCC model boundary. The model includes industrial (PWCC, other future mining and power plants) and agricultural pumping, however, the focus was on future municipal withdrawals.

Model domains are shown on **Figure WR-9.1**. Key features of each model are summarized in **Table WR-9.2**, below.



GROUNDWATER FLOW MODEL BOUNDARIES

Northeastern Arizona

Figure WR-9.1

Table WR-9.2, Key Model Features

PARAMETER	USGS Model (Thomas 2002)	PWCC Model (Tetra Tech 2015)	WNHN-N Model (HDR 2003b)
Area	5,573 mi^2	7,450 mi^2	21,607 mi^2
Model	MODFLOW 2000	MODFLOW-NWT 2011 Groundwater Vistas (Version 6.46)	MODFLOW 1996 MODFLOW^{Win32} Groundwater Vistas (Version 3.30)
Grid Orientation Columns/Rows Size	NE-SW Variable (2,640 ft x 2,640 ft min; 24,606 ft x 24,606 ft max.)	N45°E 175/145 Variable (1,640 ft x 1,640 ft min.)	N-S 297/291 2,640 ft x 2,640 ft
Layers	1	7	5
Calibration	Steady-state (pre 1965) and Transient (1965-1999) Zonal parameter distribution. Manual parameter adjustment	Steady state (pre-1956) and Transient (1956-2012) Pilot point parameter distribution (Navajo Ss) Automated (PEST) and manual parameter adustment	Steady State (pre-1955) and Transient (1956-2000) Zonal parameter distribution Manual parameter adjustment
Hydraulic Properties (N-Aquifer) K_h S_y; S_s	0.1-1.8 ft/day 0.1, 4x10-7	0.075 to 5 ft/day 0.1-0.13; 3.05 x 10-7	0.001 to 2 ft/day 0.1; 1 x 10-7
N-Aquifer Recharge Consistent Areas[1]	13,400 afa	10,900 afa	23,250 afa
Outflows to springs and canyons (N) Consistent Areas[1]	7,010 afa	12,500 afa	10,500 afa
Diffuse ET Consistent Areas[1]	6,550 afa	2,400 afa	9,000 afa
Total Inflow/Outflow-1956-2000 Consistent Areas	18,500/18,700 afa	15,000/14,900 afa	26,500/26,700 afa
Boundaries	All no flow except GHB to simulate flow from D- to N-Aquifer MODFLOW River Package for streams and rivers MODFLOW Drain Package for seeps and springs	Northeastern – General Head (GHB) and Specified Flow Boundaries Others – No flow MODFLOW River Package for recharge to D-Aquifer MODFLOW Streamflow-Routing Package (SFR) for major springs and streams MODFLOW Drain Package for minor springs and seeps	All no flow MODFLOW River Package for rivers and streams MODFLOW Drain Package for springs
Calibration Targets[2]	126 steady-state well water levels and 3 streams and 1 group of springs, 331 water levels from 38 transient water levels	8,895 water levels; 6,961 N-Aquifer, 1,537 N- and D- Aquifer, 147 D-Aquifer, 118 springs and washes; 8 streamflow and 4 spring discharges	107 D and 322 N pre-development, steady-state water levels; 2,373 transient water-levels from 37 wells

1. Tetra Tech 2015 and WNHN (HDR 2003b Table 26).
2. Tetra Tech 2014 Table 3.2-1; Thomas 2002 Tables 16 – 19; HDR 2003b Table 15.

As noted above, a problem with the layering of WNHN model prevented the USGS from converting the WNHN model to run with current versions MODFLOW. However, the USGS was able to make some observations about the strengths and weaknesses of the WNHN model in comparison to the other two models.

The USGS review scope of work included the following criteria:

- Appropriateness of boundary conditions for simulating drawdown and capture of outflow that may occur as a result of groundwater pumping
- Ability of the model to simulate major groundwater outflow points and areas using head-dependent model boundaries
- Appropriateness of hydraulic conductivity and storage properties, as indicated by the model calibration and prior knowledge of these properties
- Comparison of simulated spatial distributions of groundwater recharge to spatial and temporal distributions of recharge developed by an existing independent recharge modeling method
- The degree to which uncertainty in model predictions are quantified
- The amount of work required to modify the model for defensible application for purposes of the EIS

Findings and conclusions of the USGS review are summarized below.

1. Given the ephemeral nature of most of the streams on Black Mesa, the use of the MODFLOW River or Drain packages to simulate groundwater-surface water interaction with these streams will result in incorrect calculation of capture from groundwater pumping. The correct MODFLOW package for use in this environment is the Streamflow-Routing Package (SFR) or Streamflow Package (STR) based on technology currently available.

2. The USGS Black Mesa Model is a one-layered model and cannot simulate the effects of pumping on springs and other features connected to the D-Aquifer. Also, the model was constructed before the availability of the SFR or STR packages (and uses the River Package). These deficiencies preclude its use for the NGS-KMC EIS.

3. The WNHN Model has the best (largest) overall domain for general use in the NGS-KMC EIS. However, the layer-surface problems preclude its use. Furthermore, the WNHN Model utilizes the River Package and has the same drawback as the USGS Model in accurately simulating ephemeral stream groundwater-surface water interactions.

4. The PWCC Model is a recently calibrated model that can simulate the effects of past and future groundwater development in the D- and N-Aquifers in the Black Mesa area. The USGS review found no major problems with the PWCC Model that would limit its usefulness to the NGS-KMC EIS Team.

   The USGS recommended that the NGS-KMC EIS team look at (1) computed drawdown along any no-flow boundary segments, and (2) computed flow to any artificial boundaries represented with the Drain Package. Any significant drawdown along an artificial no-flow boundary will mean that computed results of drawdown and change in groundwater outflow will be overestimated. Similarly, any significant change in outflow to an artificial Drain Boundary will mean that drawdown and changes in outflow will be underestimated within the model domain. In contrast, insignificant drawdown and change in flow at no-flow and drain boundaries mean that these artificial boundaries have not had an effect on computation of drawdown and change in outflow within the model domain. These considerations were addressed and are discussed in subsequent pages.

5. An evaluation of long-term effects of hypothetical pumping in the coal lease area was carried out to understand the timing of “global capture’, defined as the reduced discharge to all springs, streams and evapotranspiration. The USGS found that the PWCC model predicts that maximum global capture occurs about 30 years after mine pumping stops. The USGS concluded that for estimation of maximum global capture after pumping stops, a post-pumping analysis period of 50-100 years likely would be sufficient.

Based on the USGS review and conclusions, the PWCC 3-D Groundwater Flow Model of the D- and N-Aquifers was utilized by the NGS-KMC EIS Team to assess the direct, indirect and cumulative impacts of groundwater withdrawals on the D- and N-Aquifers on and near Black Mesa.

PWCC MODEL USE AND PERFORMANCE

The latest version of the PWCC key model inputs, outputs and performance are discussed below.

DEMANDS

Pumping in the model includes water for KMC operations through 2057, as given in Table WR-9.1, and non-mine (community and windmill) withdrawals. Based on the finding by the USGS that mine effects would be captured within 50 to 100 years after pumping ceased, the model was run through 2110. Non-mine pumping was compiled from USGS records, where available, through 2011 and projected through 2110.

Non-mine pumping includes stock water and municipal withdrawals. Stock water is largely produced by windmills and is not metered. For purposes of estimating this demand in the model, all windmills were assumed to pump at the same annual rate of 0.236 ac-ft/yr over the modeled period. There are 267 model-simulated windmills in the D-and N-Aquifers, for a total annual withdrawal of approximately 63 ac-ft/yr.

In 2011 the USGS estimated community withdrawals to be about 3,090 ac-ft/yr (Macy and Unema 2014). To project community use to 2110, AECOM developed, in cooperation with the Navajo Nation, Hopi Tribe, BIA, OSMRE and USBR, a detailed procedure for estimation of population growth and corresponding per capita use, by community, for input to the model. The adopted approach included an annual population growth rate of 1.3 percent and an eventual (ramped up) per capita use rate of 120 gallons per day (gpcd) at major growth centers. This procedure resulted in a total 2110 estimated community annual withdrawal in the model of approximately 17,600 ac-ft) (AECOM 2014).

WATER LEVELS

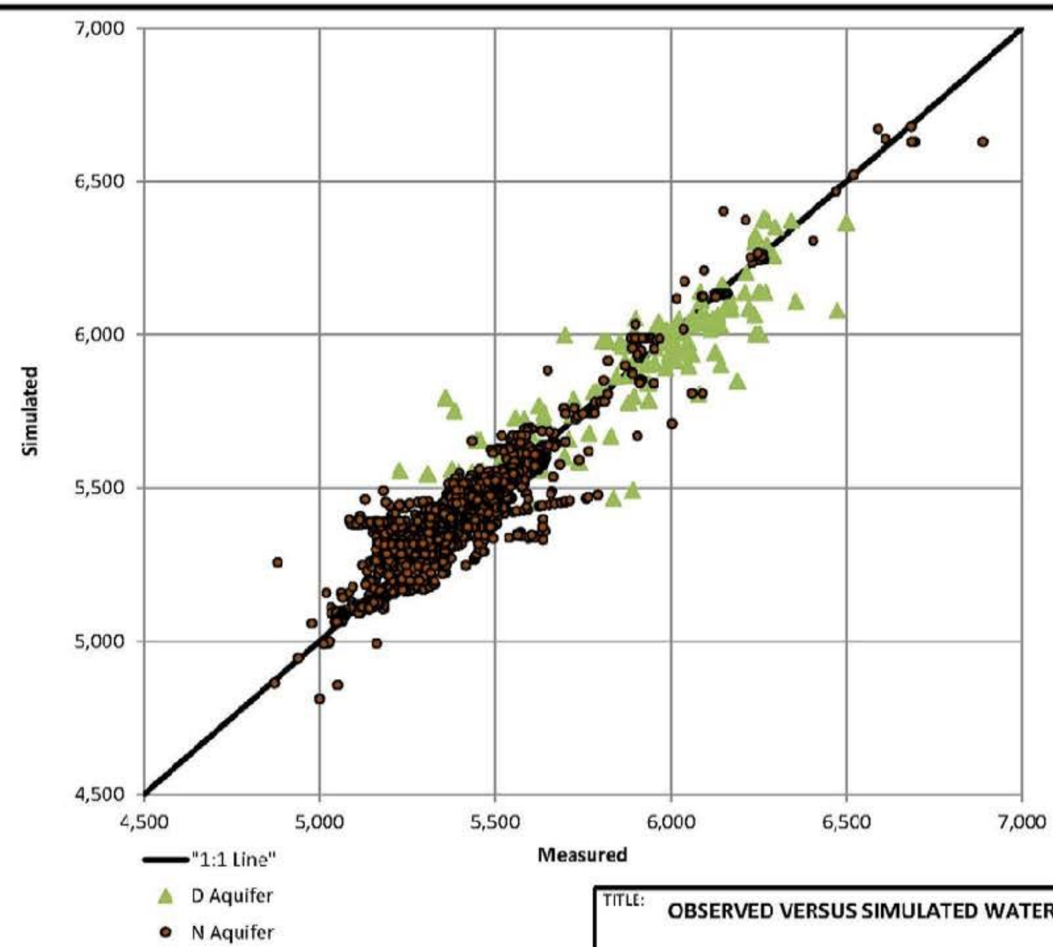
Calibration of hydraulic heads in the PWCC model can be assessed by a plot of observed versus simulated heads within the model domain. **Figure WR-9.2** shows the observed versus simulated water level elevations for the D-and N-Aquifers. Under perfect simulation conditions all points would fall on the 45-degree, 1:1 line. The poorer the agreement at a particular point, the further the point from the line. The higher degree of scatter for the D-Aquifer points indicates a somewhat lower accuracy for simulation of the D-Aquifer than for the N-Aquifer. There is slight bias in the D-Aquifer simulation with water levels being under simulated, particularly at higher elevations. There is little bias in the N-Aquifer water levels and more than 50 percent of the simulated N-Aquifer water levels are within 20 ft of their measured values. Hydrographs of observed versus simulated N-Aquifer wells are presented on **Figure WR-9.3**. Model calibration statistics for the total model are given in **Table WR-9.3**.

Table WR-9.3, Hydraulic Head Model Calibration Statistics

Parameter	Value[1]
Mean Residual (MR)	-0.17
Mean Weighted Residual (MWR)	0.22
Root Mean Square Error (RMSE)	52.16
Root Mean Square Weighted Error (RMSWE)	85.75
ASTM Root Mean Square Weighted Error (ASTM RMSWE)	75.13
RMSE/Range	2.26%
RMSWE/Range	3.71%
ASTM RMSWE/Range	3.25%

1. feet, unless otherwise noted

The observed range in heads in the model is approximately 2,310 ft. Although the ability of a model to match observed heads is a function of the complexity of the groundwater system being modeled, values of RMSE/Range and RMSWE/Range less than 10 percent are considered to indicate good agreement (Tetra Tech 2014).



TITLE:	OBSERVED VERSUS SIMULATED WATER LEVEL ELEVATIONS (1:1 LINE)
LOCATION:	Peabody Western Coal Company

TETRA TECH

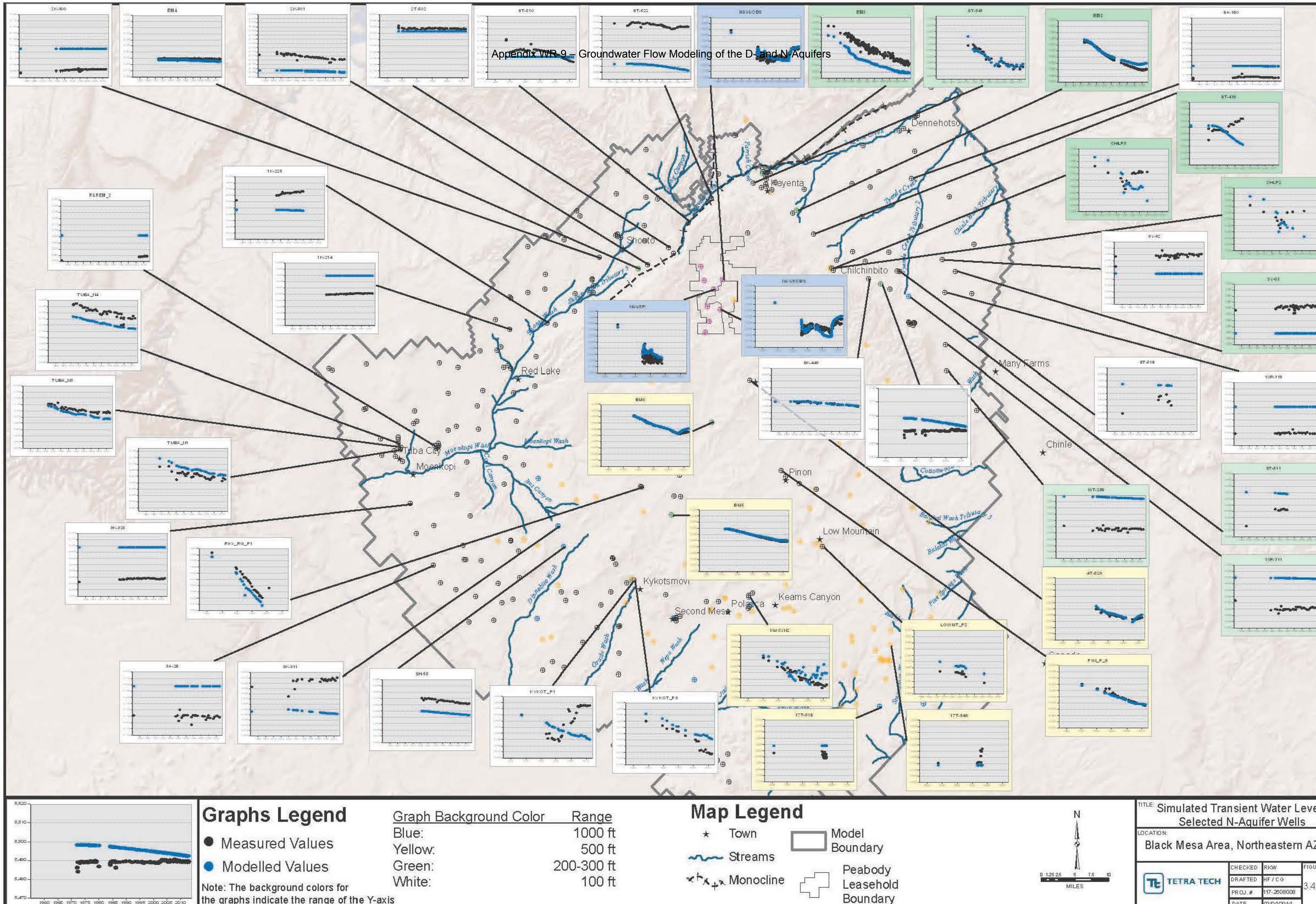
APPROVED	RKW	FIGURE
DRAFTED	AW	3.4-2
PROJECT #	117-2608008	
DATE	12/18/14	

OBSERVED VERSUS SIMULATED WATER LEVEL ELEVATIONS

Northeastern Arizona

Figure

WR-9.2



SIMULATED TRANSIENT WATER LEVELS SELECTED N-AQUIFER WELLS

Northeastern Arizona

Figure WR-9.3

This page intentionally left blank

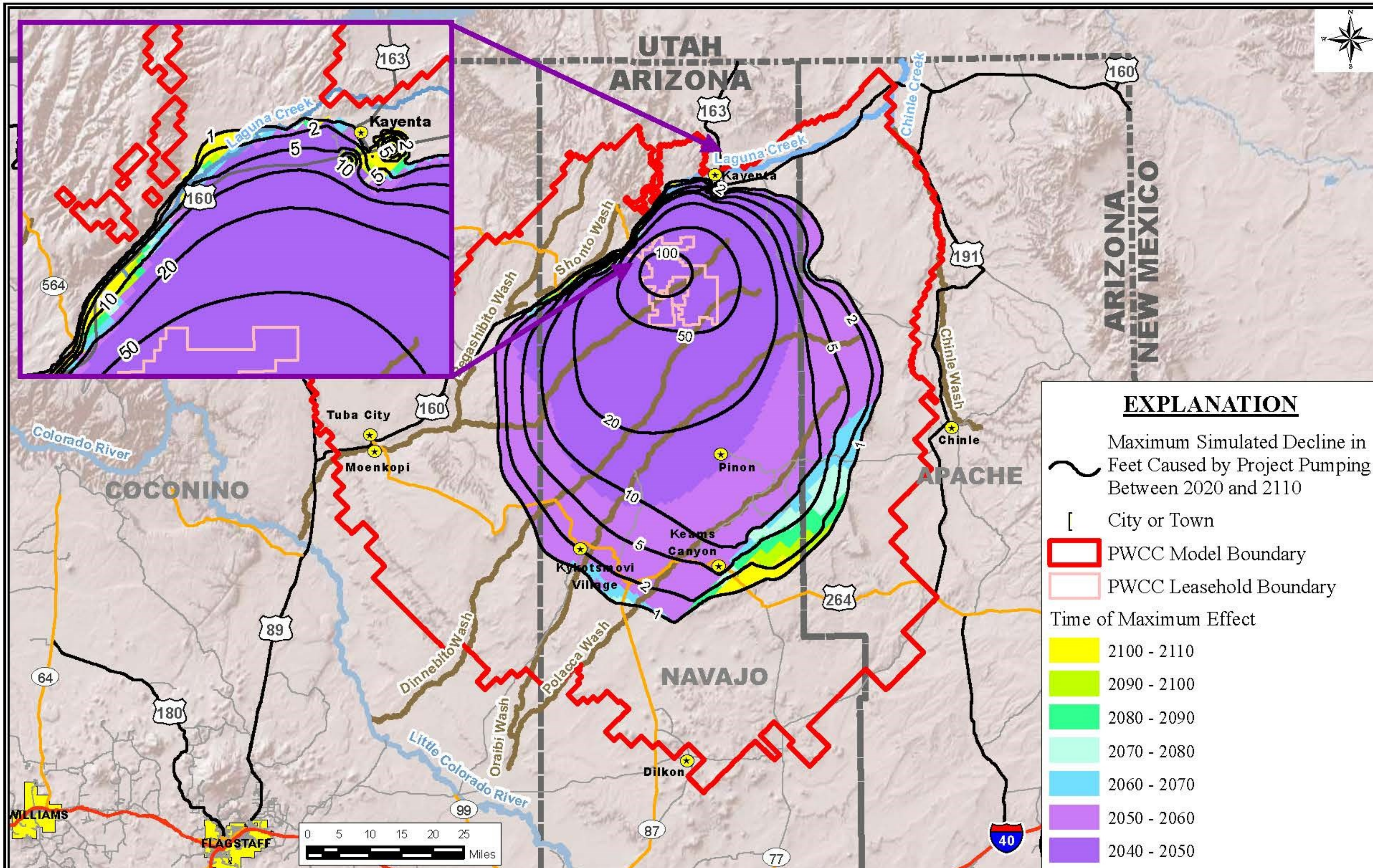
N-Aquifer hydraulic heads in the model (Layer 5) were extracted to assess impacts due to pumping. The model was run with two alternative pumping scenarios:

1. **No Action –** Coal mining continues through 2019 with pumping at 1,200 ac-ft/yr, followed by 500 ac-ft/yr from 2020 through 2022 and 100 ac-ft/yr from 2023 through 2033 for mine reclamation.
2. **Proposed Action –** Mine operation continues through 2044 at 1,200 ac-ft/yr followed by three years at 500 ac-ft/yr and ten years at 100 ac-ft/yr (Table WR-9.1).

Thus, the No Action scenario considers a total pumping volume of 2,500 acre-feet. From 2019 through 2004, the total pumping volume in the Proposed Action scenario would be 32,500 acre-feet. The impact assessment is based on the difference between these scenarios of 30,000 acre-feet. Changes to N-Aquifer water levels due to KMC pumping were calculated by subtracting the heads from the Proposed Action scenario from the heads generated by the No Action scenario. This approach ensured that any non-linearity in model parameters (such as transmissivity) due to changes in water level would not bias model outputs.

The cone of depression due to PWCC pumping spreads over time: while water levels in wells at and near the mine started to recover (rise) in 2007 due to a decrease in PWCC pumping, water levels distant from the KMC continue to decline. Thus, the maximum impact due to project pumping occurs at different times at different locations, as shown on **Figure WR-9.4**. This figure shows that the 1.0 ft drawdown contour under maximum project pumping does not reach any of the model no-flow boundaries, indicating that modeled drawdown is not likely to be overestimated (see Item 4 under USGS Review).

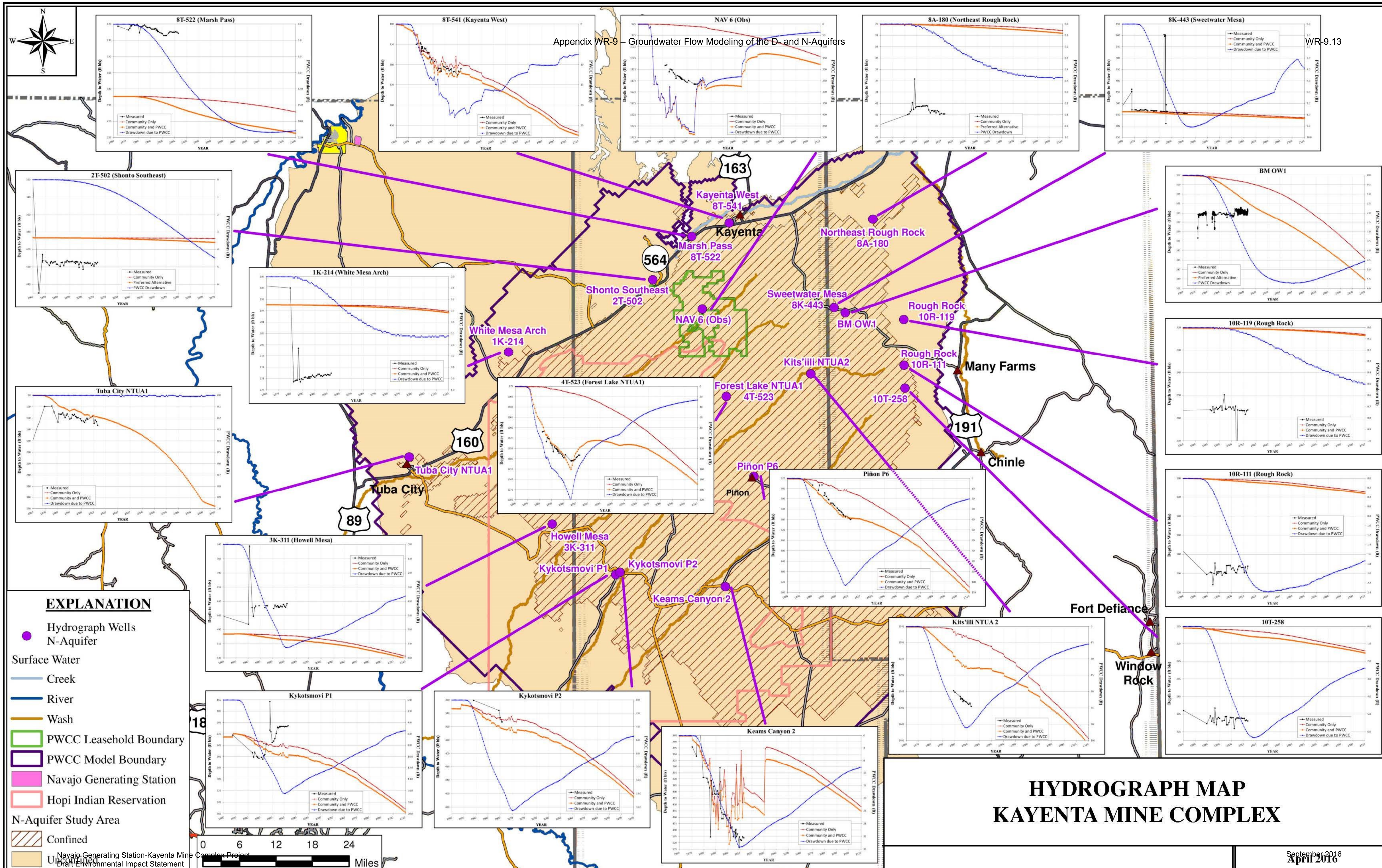
Hydrographs at selected N- and D-Aquifer well locations were prepared to allow visualization of the changes in water level in the N- and D-Aquifers over the modeled period. Pumping in the model includes past, present and future PWCC, community and windmill withdrawals. Locations were selected to provide a broad coverage of the N-Aquifer within the PWCC Black Mesa Groundwater Flow Model domain and, where historic data were available, to compare modeled to measured water levels. Coverage of the D-Aquifer is limited by the lack of wells and water level data. Hydrographs and their location are shown on **Figure WR-9.5**.



N-AQUIFER MAXIMUM PROJECT PUMPING DRAWDOWN MAP

Northeastern Arizona

Figure WR-9.4


HYDROGRAPH MAP
KAYENTA MINE COMPLEX
April 2016
8T-522 (Marsh Pass)
8T-541 (Kayenta West)
NAV 6 (Obs)
8A-180 (Northeast Rough Rock)
8K-443 (Sweetwater Mesa)
BM OW1
2T-502 (Shonto Southeast)
1K-214 (White Mesa Arch)
10R-119 (Rough Rock)
Tuba City NTUA1
4T-523 (Forest Lake NTUA1)
Piñon P6
10R-111 (Rough Rock)
3K-311 (Howell Mesa)
Kits'iili NTUA 2
10T-258
Kykotsmovi P1
Kykotsmovi P2
Keams Canyon 2
Measured
Community Only
Community and PWCC
Preferred Alternative
Drawdown due to PWCC
PWCC Drawdown
Depth to Water (ft bls)
PWCC Drawdown (ft)
YEAR
Kayenta West 8T-541
Kayenta
Marsh Pass 8T-522
Northeast Rough Rock 8A-180
Shonto Southeast 2T-502
Sweetwater Mesa 8K-443
BM OW1
Rough Rock 10R-119
NAV 6 (Obs)
White Mesa Arch 1K-214
Rough Rock 10R-111
Kits'iili NTUA2
Forest Lake NTUA1 4T-523
10T-258
Many Farms
Chinle
Tuba City NTUA1
Tuba City
Piñon P6
Piñon
Howell Mesa 3K-311
Kykotsmovi P1
Kykotsmovi P2
Keams Canyon 2
Fort Defiance
Window Rock
163
564
160
191
89
EXPLANATION
Hydrograph Wells N-Aquifer
Surface Water
Creek
River
Wash
PWCC Leasehold Boundary
PWCC Model Boundary
Navajo Generating Station
Hopi Indian Reservation
N-Aquifer Study Area
Confined
Unconfined
0 6 12 18 24
Miles

This page intentionally left blank

Data in the hydrographs are from a number of sources as noted in **Table WR-9.4**.

Table WR-9.4, Sources of Data

Data	Source
Well name and location	USGS Black Mesa Monitoring Program Open-file Reports (compiled by TetraTech) PWCC (Mine NAV Wells) NTUA Report of Wells (2011) ADWR Hopi HSR (ADWR 2008)
Measured water levels	USGS Black Mesa Monitoring Program Open-file Reports (compiled by TetraTech) NWIS NTUA/NNDWR HydroGeo Chem S.S. Papadopulos
Well surface elevation	USGS Black Mesa Monitoring Program Open-file Reports NTUA Report of Wells (2011) ADWR Hopi HSR (ADWR 2008)
Modeled water levels	PWCC Groundwater Flow Model (Tetra Tech 2015)

1.

Four (4) data series (where available) are plotted on each hydrograph. Data series are described in **Table WR-9.5**.

Table WR-9.5, Hydrograph Data Series

Data Series	Description	Plotted Axis
Measured	Where available, measured water levels are shown for the period of record. Variations in water levels from year-to-year may be due to local pumping or measurement error.	Given in depth-to-water below land surface and plotted on the left Y-axis
Community Only	Annual water levels from the PWCC Model were extracted for the period 1956-2110 for a simulation without PWCC withdrawals. Historic community pumping is as reported by the USGS; future community pumping is from projections made by the EIS team based on population and per-capita use (AECOM 2014). A constant value is used to represent windmills.	Given in depth-to-water below land surface and plotted on the left Y-axis
Community and PWCC	Annual water levels from the PWCC Model were extracted for the period 1956-2110 for a simulation with both Community (historic and projected) and PWCC withdrawals (also includes windmills).	Given in depth-to-water below land surface and plotted on the left Y-axis
Drawdown due to PWCC	The difference between Community and PWCC and Community Only simulation water levels.	Given in feet (difference between pre-pumping and pumping water level). Plotted on the right Y-axis

Attachment A presents hydrographs for 23 wells and one spring (1A-88). A map showing the location of the wells and spring is also provided. Hydrographs for the following wells (and spring) are presented.

Hydrograph Figure No.	Name
1	Location Map
N-Aquifer	
2	4T-523 (Forest Lake NTUA1)
3	3K-311 (Howell Mesa)
4	8T-541 (Kayenta West)
5	Keams Canyon 2
6	Kits'iili NTUA 2
7	Kykotsmovi P1
8	Kykotsmovi P2
9	8T-522 (Marsh Pass)
10	Piñon P6
11	10R-119 (Rough Rock)
12	10T-258
13	10R-111 (Rough Rock)
14	8K-443 (Sweetwater Mesa)
15	1K-214 (White Mesa Arch)
16	Tuba City NTUA1
17	2T-502 (Shonto Southeast)
18	8A-180 (Northeast Rough Rock)
19	BM OW1
20	NAV 6 (Obs)
D-Aquifer	
21	4T-402
22	8T-503 (Chilchinbito)
23	Low Mtn P1
24	Kykotsmovi PM1
25	1A-88 (Red Lake – Spring)[1]

1. No well exists at Red lake, a possible spring location was selected to represent model simulated water level change

Review of the hydrographs yields the following findings:

1. N-Aquifer pre-pumping simulated depth-to-water varies significantly over the area from 925 feet below land surface (ft bls) near the PWCC Leasehold (NAV 6 OBS and 4T-523 [Forest Lake NTUA 1]) to 29 ft bls at 8A-180 (Northeast Rough Rock).

2. N-Aquifer simulated water levels throughout the model domain decline over the modeled period due to projected continually increasing Community water demands. Community

withdrawals are projected to increase based on population and per capita water use numbers developed by the EIS Team (AECOM 2014).

3. Drawdown due to PWCC withdrawals reaches a maximum at different times due to aquifer conditions and distance and from the PWCC leasehold supply wells. The latest year of simulated maximum drawdown is 2110 at 2T-502 (Shonto Southeast) with a drawdown of approximately 4.5 ft. Maximum simulated drawdown in a Community well due to PWCC pumping occurred at 4T-523 (Forest Lake NTUA 1) in 2006 as a response to past PWCC withdrawals.

4. The effect of PWCC withdrawals is apparent in hydrographs of wells close to the leasehold. Wells NAV 6 OBS and 4T-523 (Forest Lake NTUA 1) show a decline in water level in response to PWCC pumping until 2006, after which drawdown decreases rapidly and then more slowly until significant withdrawals end in 2044; drawdown due to PWCC pumping decreases steadily thereafter.

5. In all but three (3) of the N-Aquifer wells (2T-502 [Shonto Southeast], 10R-119 [Rough Rock] and 8A180 [Northeast Rough Rock]), the drawdown due to PWCC pumping decreases after 2090, with most wells showing a reduction after 2010 (i.e., water level recovery) due to closure of the coal slurry pipeline in 2005 and consequent reduction in PWCC withdrawals.

6. Four (4) of the N-Aquifer wells (10R-119 [Rough Rock], 1K-214 [White Mesa Arch],Tuba City NTUA 1, 8A-180 [Northeast Rough Rock] and one(1) D-Aquifer spring (1A-88) appear to be in the unconfined portions of their respective aquifer and show little drawdown due to PWCC withdrawals. The maximum simulated drawdown due to PWCC withdrawals in these wells/spring is 0.53 ft (1K-214 White Mesa Arch).

7. The ‘fit’ between measured and modeled water levels is variable in terms of absolute value of depth-to-water and the trend over the measured period. The following general observations are noted:

    a. fit between absolute depth-to-water and trend are very good in wells: 4T-523 (Forest Lake NTAU 1), Pinon P6, 8T541 (Kayenta West), Keams Canyon 2, Kykotsmovi P2, Tuba City NTUA 1 and 8K-443 (Sweetwater Mesa). With exception of 8K-443 (Sweetwater Mesa), these wells are in the areas of highest PWCC and Community pumping.
    b. fit to trend is good in NAV 6 OBS, 10R-119 (Rough Rock), 10T-258, Kits’iilli NTUA 2, 2T-502 (Shonto Northeast), 8T-522 (Marsh Mesa). The fit to absolute water level (simulated – measured) in the wells ranges from +70 to -116 ft
    c. in the northeast, with the exception of 8K-443 (Sweetwater Mesa), simulated water levels are generally shallower than measured water levels by eight (8) to 195 ft (8A-180, BM OW1, 10R-119, 10R-111 and 10T-258).
    d. the poorest fit with absolute value and trend is in 1K-214 (White Mesa Arch), 8A-180 (Northeast Rough rock), BM OW 1 and Kykotsmovi P 1.

In general, the model best simulates historic water level absolute values and trends in areas where the N-Aquifer is comprised mostly of the Navajo Sandstone, e.g. beneath the leasehold and in the central portions of the Black Mesa structural basin. Near the edges of the basin the Navajo Sandstone thins and intertongues with the Kayenta formation and the aquifer moves from confined to unconfined (water table) conditions. The model represents the Navajo Sandstone and the Kayenta Formation each as a single numerical model layer. This means that wells completed in both units or near the confined/unconfined boundary are not as well simulated as those that are entirely within a single unit and/or hydraulic property (confined/unconfined) area.

STREAMFLOW

Streams on Black Mesa are ephemeral or intermittent over most of their reaches. There are isolated perennial reaches supported by D- and N-Aquifer groundwater discharge (baseflow) where the streams cross the confined/unconfined aquifer boundary. These stream baseflows are simulated with the MODFLOW Streamflow-Routing Package (SFR2), the most appropriate package for streams of this type (see Item 1 under "USGS Review"). Location of the streams and the segments simulated in the model are shown on **Figure WR-9.6**.

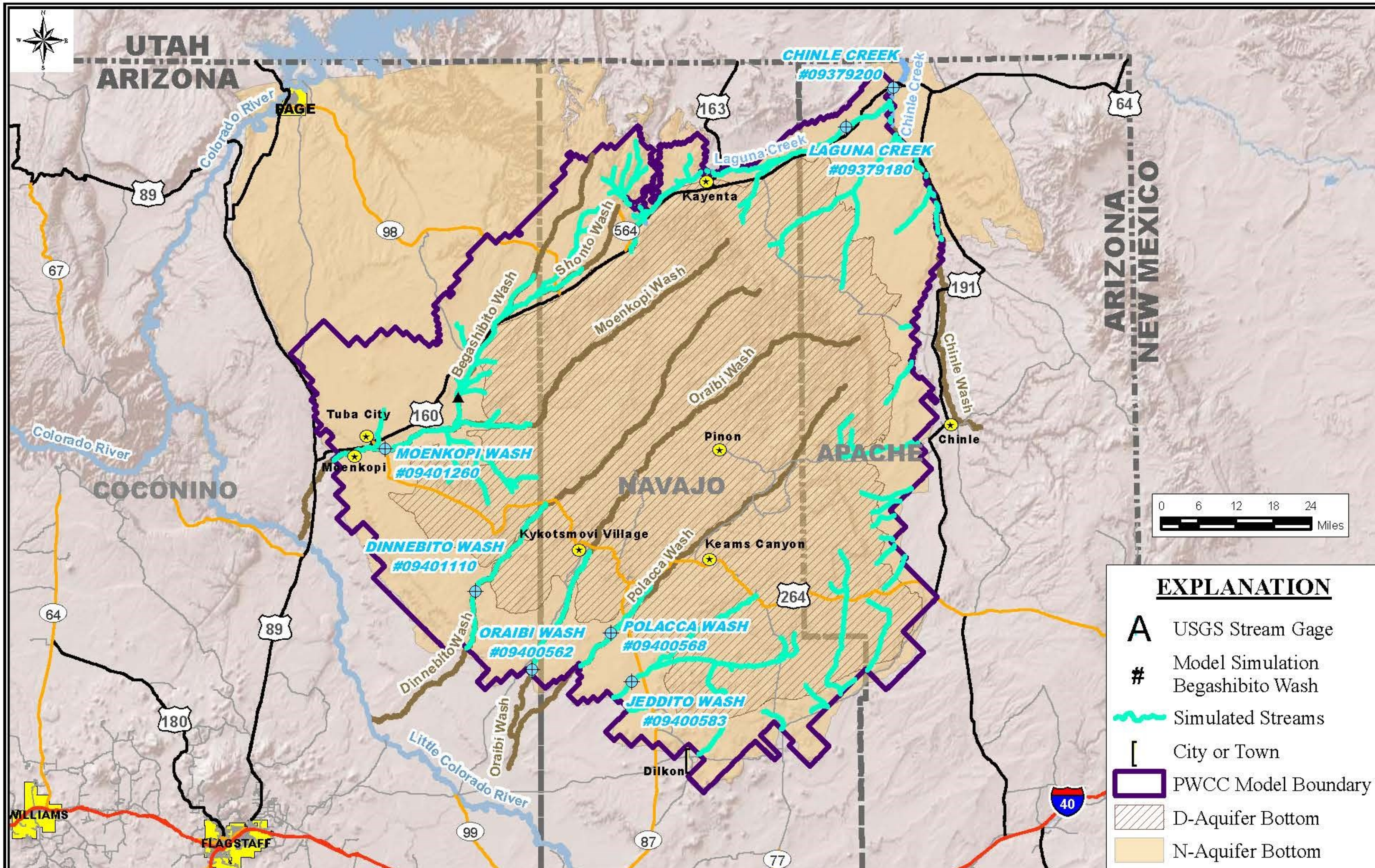
In addition to the seven (7) simulated stream baseflows, four (4) spring locations are also simulated using the Streamflow Routing Package. These springs have been monitored by the USGS as part of the Survey's Black Mesa Monitoring Program since the late 1980's (Macy and Unema 2014) and were utilized as calibration targets in the model (Tetra Tech 2015, 2014). Model calibration statistics for these streams/springs are given in **Table WR-9.6**.

Table WR-9.6, Stream/Spring Model Calibration Statistics

Parameter	Value[1]
Mean Residual (MR)	-8,717.0
Mean Weighted Residual (MWR)	-14.6
Root Mean Square Error (RMSE)	45,249.4
Root Mean Square Weighted Error (RMSWE)	301.7
ASTM Root Mean Square Weighted Error (ASTM RMSWE)	121.9
RMSE/Range	13.67%
RMSWE/Range	0.09%
ASTM RMSWE/Range	0.04%

1. Cubic feet per day, unless otherwise noted.

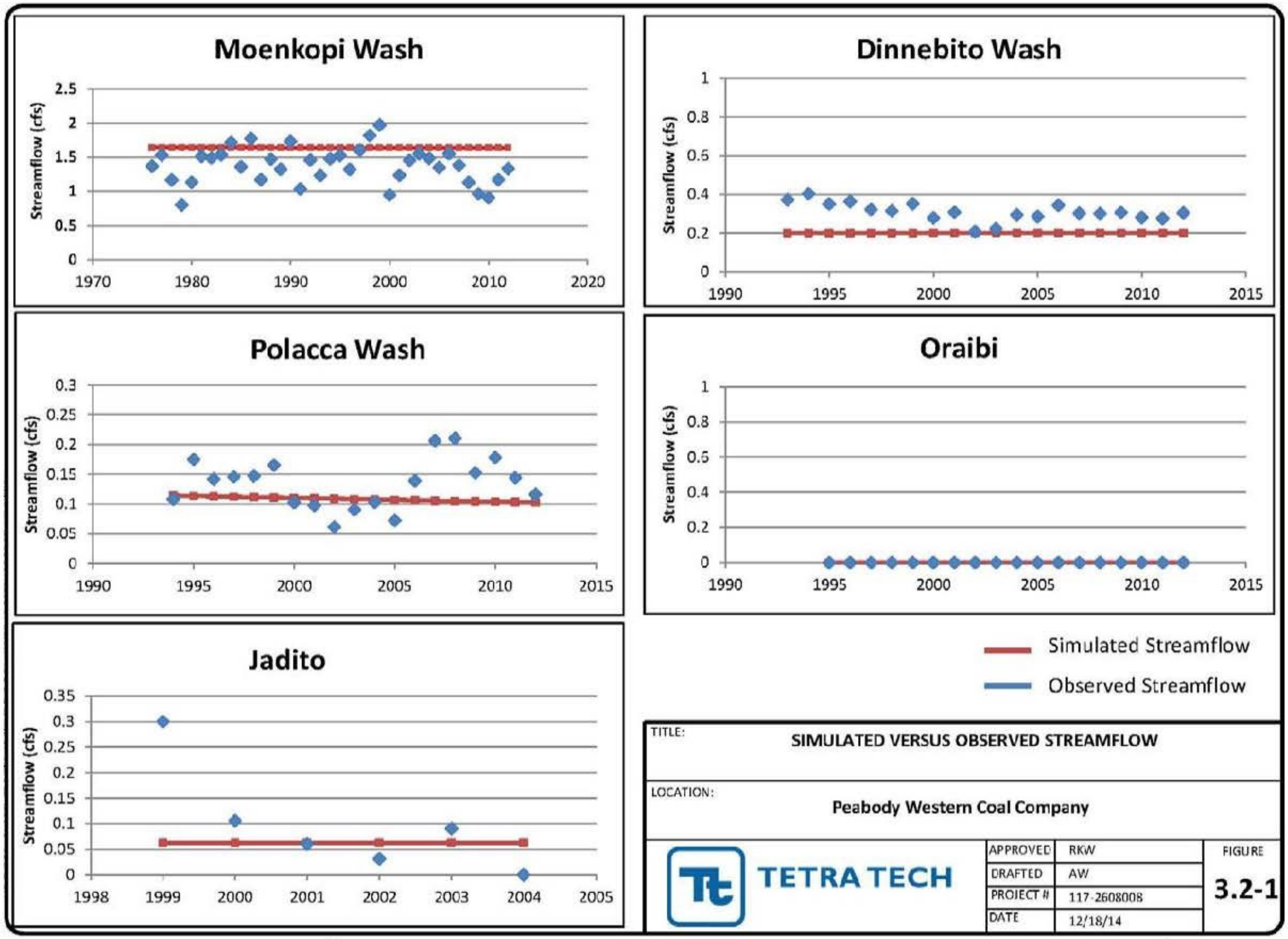
The range in observed stream baseflow is approximately 331,085 cubic feet per day (cfd). Both the MR and MWR values are negative, indicating that the model generally under-simulates streamflow and spring discharge at the observed locations. Plots of observed versus simulated annual stream baseflow are given on **Figures WR-9.7A** and **WR-9.7B**. Model predicted flows and change due to all (PWCC, community and windmill) pumping from 1956 to 2019 and change due to proposed mine-related project pumping (2020 to 2110) are given in **Table WR-9.7**.



SIMULATED STREAMS AND STREAM GAGES

Northeastern Arizona

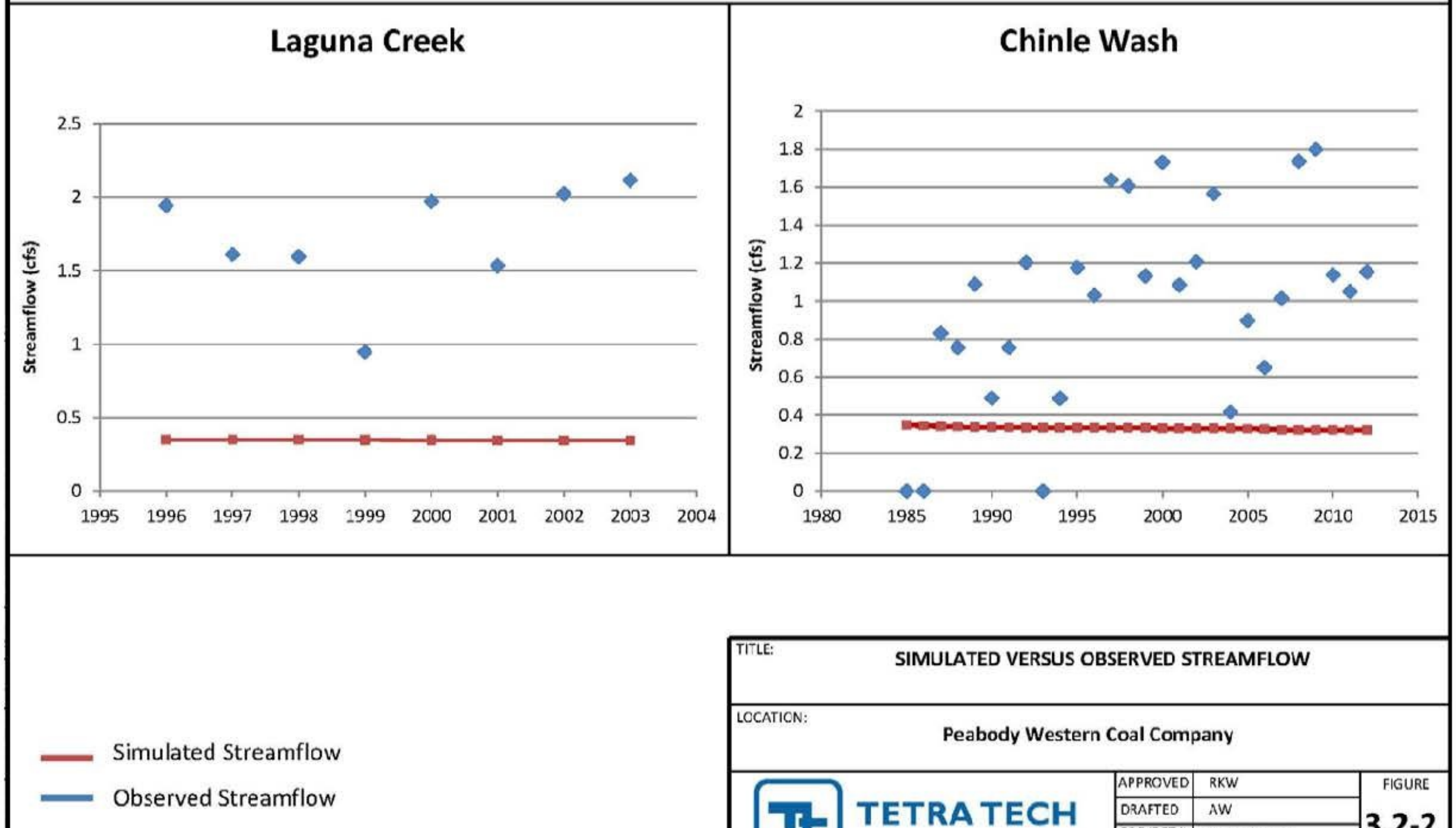
Figure WR-9.6



SIMULATED VERSUS OBSERVED ANNUAL STREAM BASEFLOW

Northeastern Arizona

Figure WR-9.7A



TITLE: SIMULATED VERSUS OBSERVED STREAMFLOW			
LOCATION: Peabody Western Coal Company			
TETRA TECH	APPROVED	RKW	FIGURE 3.2-2
	DRAFTED	AW	
	PROJECT #	117-2608008	
	DATE	12/18/14	

SIMULATED VERSUS OBSERVED ANNUAL STREAM BASEFLOW

Northeastern Arizona

Figure WR-9.7B

Table WR-9.7, Model Predicted Baseflow and Change Due to Project Pumping

Location	USGS Station No.	1956 (cfs)	End of 2019 (cfs)	Difference (cfs)	Projected Change Due to Project Pumping, 2020-2110 (cfs)	Percent Change Due to Project Pumping, 2020-2110
Moenkopi Wash	09401260	1.641	1.637	-0.004	-0.0004	-0.02
Dinnebito Wash	09401110	0.198	0.200	0.002	0.0000	0.00
Polacca Wash	09400568	0.124	0.099	-0.025	-0.0007	-0.71
Chinle Creek	09379200	0.348	0.309	-0.0105	-0.0027	-0.87
Jeddito Wash	09400583	0.063	0.062	-0.001	0.0000	0.00
Begashibito Wash	NA	0.119	0.101	-0.018	0.0000	0.00
Laguna Creek	09379180	0.364	0.326	-0.038	-0.0027	-0.83

Maximum predicted impact on stream baseflow is about 0.9 percent of the 2019 baseflow value. As noted, the model tends to under-simulate the baseflow; the reason for this is not certain. If the under-simulation is due to low stream conductance, the simulated reduction in baseflow could be under-estimated; if it is due to low water levels the impact could be over-estimated. However, given the small level of simulated impact, even a doubling of the reduction in baseflow would still be small percentage change.

Predicted change in stream baseflow as a result of proposed project pumping is small due to distance from the mine pumping wells and the unconfined aquifer conditions at the location of perennial flow (baseflow).

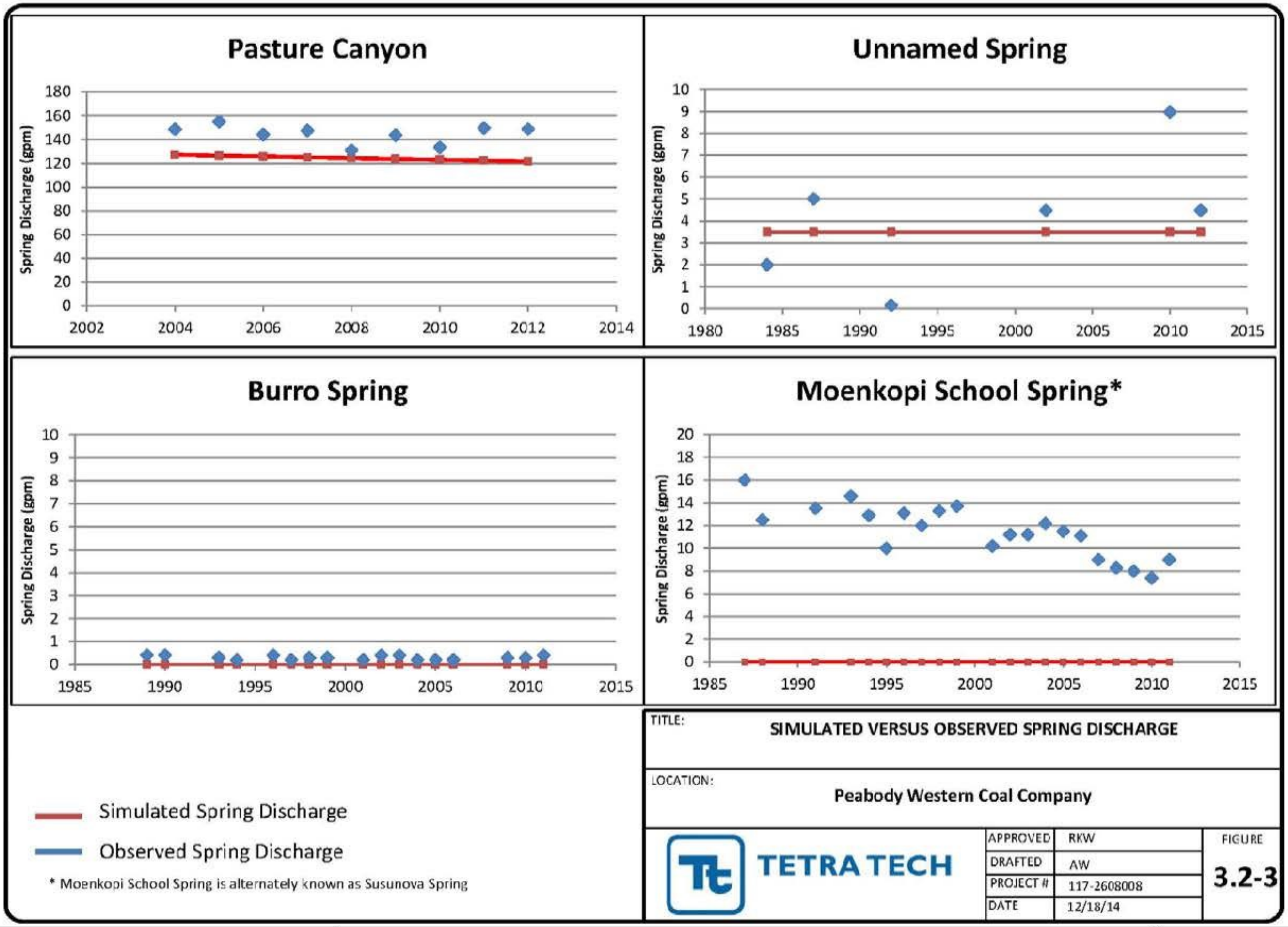
SPRINGS

Four (4) springs are monitored by the USGS on an annual basis, including:, Moenkopi School (Susonova), Burro (Honahnie), Pasture Canyon and Unnamed Spring near Dennehotso. These springs are simulated with the Streamflow Routing Package. Simulated versus observed spring flow is shown on **Figure WR-9.8**. **Table WR-9.8** gives 2012 measured versus modeled flows at these four springs.

Table WR-9.8. 2012 Measured Versus Modeled Spring Flow

Name	2012 Measured Flow (gpm)	2012 Model Simulated Flow (gpm)
Moenkopi School (Susonova)	6.3	0.0
Burro (Honahnie)	0.3	0.0
Pasture Canyon (measured/estimated)[1]	26.5/150	122
Unnamed near Dennehotso	4.5	3.5

1. USGS gaging station measures only a portion of the total discharge from multiple springs



SIMULATED VERSUS OBSERVED SPRING DISCHARGE

Northeastern Arizona

Figure WR-9.8

While the model is set up to simulate spring flow at Moenkopi School and Burro Springs, no flow occurs at these springs in the simulation due to limitations of the model vertical discretization at the spring locations.

The USGS describes the Moenkopi School spring as “3GS-77-6, Navajo Sandstone tongue in Kayenta Formation” implying that locally the Navajo Sandstone connects to the spring within the Kayenta Formation. The Navajo is not present in the model at the location, and the hydrogeologic characteristics of the Kayenta Formation are significantly different enough to make simulation of the observed flow rates impossible to match. Spring discharge is expected to be directly tied to groundwater level at the location. A decrease in water levels would tend to cause a corresponding decrease in discharge at the spring. Although the model does not provide the ability to simulate flow at the location of the spring, simulated water levels in model layers 5 (Navajo Sandstone) and 6 (Kayenta/Moenave Formations) where these layers are active are likely to provide appropriate surrogate water level data for the purpose of evaluating the effects of pumping. No change in water level at this spring due to project pumping is simulated in the model.

The USGS-observed baseflow from Burro Spring is approximately 0.2 to 0.4 gpm, or about 0.0004 to 0.0009 cfs. The location of Burro Spring is approximately 1,000 feet southeast of the Oraibi Wash channel, and approximately 75 to 100 feet higher in elevation. In aerial photos of the adjacent Oraibi Wash channel, the channel appears dry with some vegetation suggesting that groundwater is likely present in the shallow alluvium of the channel. This means that flow occurring at Burro Spring is likely due to groundwater being locally perched on a layer within the Navajo Sandstone. The model represents the Navajo Sandstone and the Kayenta Formation each as single numerical model layers (Layers 5 and 6). This means that simulation of perched water, or water flowing in an isolated subunit is not possible to perform, as this would require subdivision of a model layer into at least two and probably three sub-layers. For the reasons mentioned above, this condition is not possible to simulate within the framework of the model structure. Simulated drawdown at the model cell should represent an effective means of predicting spring discharge impacts at the location due to pumping assuming that the water flow to the spring is directly linked to the regional N-aquifer and not solely a product of local recharge. No change in water level at this spring due to project pumping is simulated in the model.

In addition to the four (4) USGS monitored springs simulated with the Streamflow Routing Package, 122 potential springs were simulated with the Drain Package. These springs are not monitored and little or no flow data are available. Based on a USGS spring inventory undertaken for the NGS-KMC EIS, 68 “likely” spring locations were identified by the NGS-KMC EIS Team. Since springs and seeps are important perennial water sources for irrigation, cultural and ecological purposes and many have religious or sacred values for the Navajo and Hopi people, individual spring locations are not identified in the EIS unless they have been identified in the published literature (e.g. the four USGS monitored springs). Springs are divided among 11 groups (A through I), as shown on main EIS text Figure 3.7-12.

Flow and head data for these 68 spring locations were extracted from the model and changes noted between the No Action and Proposed Action alternatives; the difference being the impact due to project pumping. Model predicted head and/or flow change is limited to 17 springs and ranges between -0.001 to -0.16 ft and -0.008 to -0.06 gpm (see main EIS text Table 3.7-20). Predicted change in head and flow is small, indicating that the drain boundaries have an insignificant effect on the calculation of drawdown and change in flow at the simulated springs (see Item 4 under USGS Review).

ASPECTS OF MODELING

Numerical groundwater flow models are acknowledged to be "non-unique", meaning that more than one set of boundary conditions and aquifer parameters can produce essentially the same 'fit' to measured conditions. In the case of the current PWCC 3-D Groundwater Flow Model of the D- and N-Aquifers, there are several aspects of model development that have constrained the selection of boundary conditions and model inputs. These are summarized below.

- The study area has been the subject of numerous hydrogeologic investigations since the late 1960s.
- There has been a rigorous annual pumping, water level, spring discharge, surface water flow and water quality data collection program by the USGS since 1971. These data have provided a reliable record of change in response to groundwater withdrawals.
- As noted in Table WR 9.2, there have been several previous models of the same area and aquifers. These models were independently developed and have provided a similar 'fit' to measured data with different model configurations.
- The current PWCC model has under gone several updates since it was originally developed in 1997. In 2012 OSMRE requested that the model be recalibrated utilizing the water level and pumping data compiled over the 16 years since the original model development (Tetra Tech 2014).
- The current model was subjected to 'peer review' by the USGS. This review "found no problems with the PWCC model that would preclude its use by the NGS-KMC EIS team".

Modeling of the response to proposed future PWCC pumping on Black Mesa has benefited from the fact that past pumping has exceeded projected pumping by a factor of 4.5. Thus, the level of stress to be imposed on the aquifers by future PWCC pumping has been measured and the model calibrated to past changes in groundwater levels. Furthermore the length of future pumping is limited to 45 years, minimizing the length of the projection period and the uncertainty associated with unknowable future conditions. .

Community pumping is projected to 2110 (98 years), the total annual pumpage increases nearly six times and exceeds the maximum PWCC past pumping by a factor of four. Thus, uncertainty in model simulation of future water level conditions beyond the end of PWCC pumping (2057) is increased.

As noted in the previous discussion of the hydrographs (item 7) presented in Attachment A, the accuracy of the simulation of past and future water levels varies through the model domain. In general the model produces good to very good 'fit' to measured water levels in the area of the leasehold and in major community pumping centers. The fit is poorer in areas distant from the leasehold and near the confined-unconfined boundary.

REFERENCES

AECOM. 2014. Memorandum of Technical Recommendation, Recommended Groundwater Modeling Inputs for Population Growth and Water Demand. September 16, 2014.

Arizona Department of Water Resources (ADWR). 2008. Preliminary Hydrographic Survey Report for the Hopi Indian Reservation. In: Re the General Adjudication of the Little Colorado River System and Source. December 2008. Internet website: http://www.azwater.gov/AzDWR/Hydrology/Library/HydrologicSurveyReports.htm. Accessed May 13, 2016.

Brown, J. G. and J. H. Eychaner. 1988. Simulation of Five Ground-water Withdrawal Projections for the Black Mesa Area, Navajo and Hopi Indian Reservations, Arizona. U.S. Geological Survey Water-Resources Investigations Report 88-4000. 51 p.

Eychaner, J. E. 1983. Geohydrology and Effects of Water Use in the Black Mesa Area, Navajo and Hopi Indian Reservations, Arizona. U.S. Geological Survey Water-Supply Paper 2201. 33 pp.

Geotrans, Inc. 2005. A Three-Dimensional Flow Model of the D and N Aquifers, Black Mesa Basin, Arizona. Supplement 1. July 2005. Prepared by Geotrans, Inc., Louisville, Colorado for Peabody Western Coal Company.

HDR Engineering, Inc. (HDR). 2003a. Report of Findings for the Assessment of Western Navajo-Hopi Water Supply Needs, Alternatives, and Impacts. N-Aquifer Computer Model Study Files. HDR Engineering, Inc. for the U.S. Bureau of Reclamation.

HDR Engineering, Inc. (HDR). 2003b. Technical Memorandum, WNH N-Aquifer (WNHN) Groundwater Flow Model, in Report of Findings for the Assessment of Western Navajo and Hopi Water Supply Needs, Alternatives, and Impacts. Volume 3, Appendix A-1. HDR Engineering, Inc. for the U.S. Bureau of Reclamation.

HDR Engineering, Inc. (HDR). 2003c. Technical Memorandum, Plan of Study Spring Impacts: Drawdown Thresholds for Use with the WNH N-Aquifer (WHNH) Groundwater Flow Model, in Report of Findings for the Assessment of Western Navajo and Hopi Water Supply Needs, Alternatives, and Impacts, Volume 3 Appendix A-2. HDR Engineering, Inc. for the U.S. Bureau of Reclamation.

HSI/Geotrans and Waterstone Environmental Hydrology and Engineering, Inc. 1999. A Three Dimensional flow Model of the D and N Aquifers, Black Mesa Basin Arizona. Report by HSI/GeoTrans and Waterstone for Peabody Western Coal Company (PWCC), September 1999.

Leake, S. A., J. P. Macy, and M. Truini. 2016. Hydrologic Analyses in Support of the Navajo Generating Station-Kayenta Mine Complex Environmental Impact Statement. U.S. Geological Survey Open-file Report 2016-1088. 23 p.

Macy, J. P. and J. A. Unema. 2014. Groundwater, Surface-Water, and Water-Chemistry Data, Black Mesa Area, Northeastern Arizona – 2011–2012: U.S. Geological Survey Open-File Report 2014–1304, 42 p., http://dx.doi.org/10.3133/ofr20131304.

Office of Surface Mining, Reclamation, and Enforcement (OSMRE). 2014. Cumulative Hydrologic Impact Assessment (CHIA), Peabody Western Coal Company, Kayenta Complex. USDOI Office of Surface Reclamation and Enforcement, Western Region, December 2011.

Tetra Tech. 2015. Predicted Effects of Pumping under the Proposed Mine Plan Revision. Report by Tetra Tech, Inc. for Peabody Western Coal Company. October 2015.

Tetra Tech. 2014. Update of Peabody Western Coal Company's Groundwater Flow Model of the N and D Aquifers, Northeastern Arizona – Version 1.0. Prepared for: Peabody Western Coal Company. January 15, 2014.

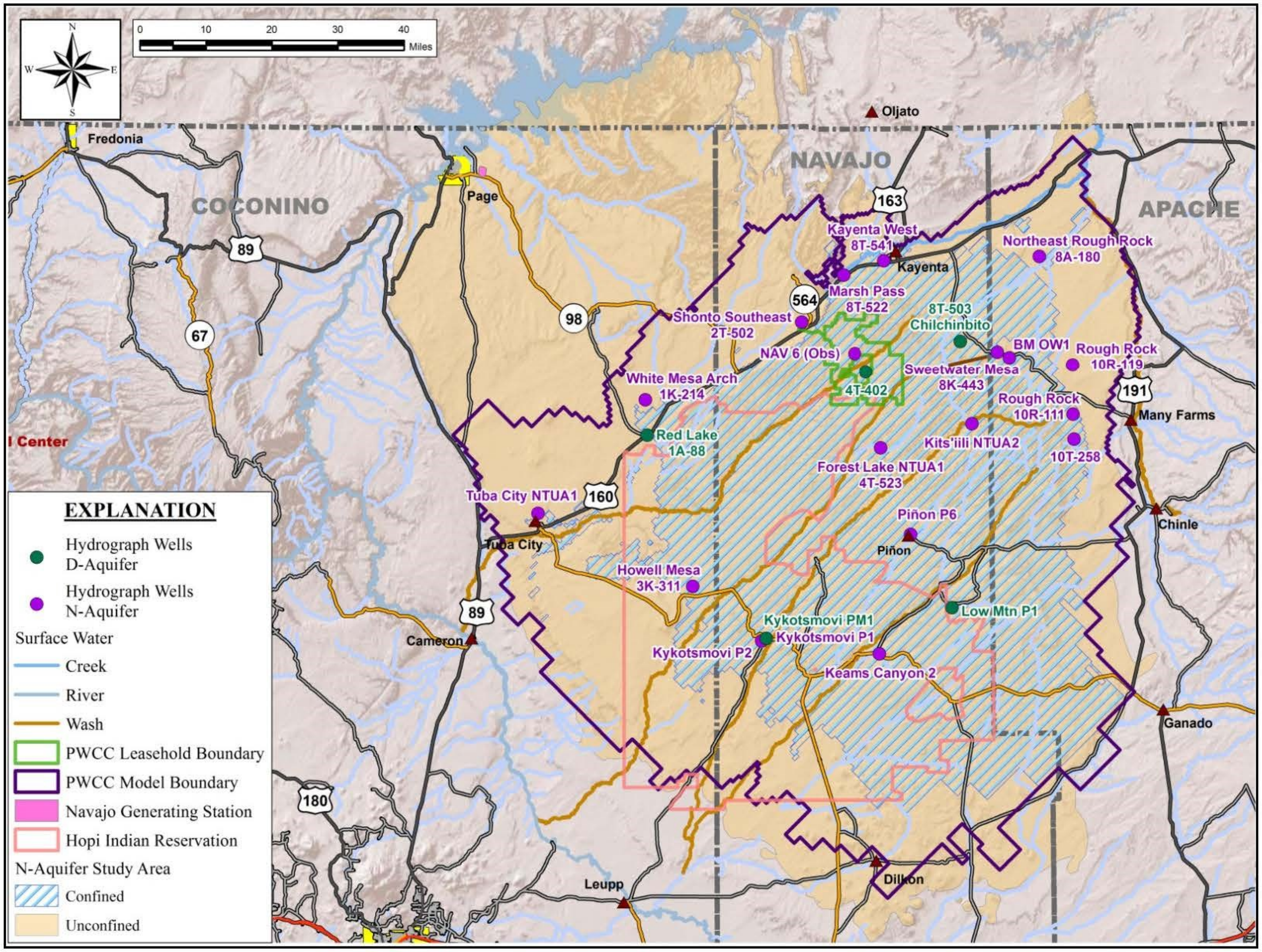
Thomas, B. E. 2002. Groundwater, Surface-Water, and Water Chemistry Data, Black Mesa Area, Northeastern Arizona – 2000-2001, and Performance and Sensitivity of the 1988 USGS Numerical Model of the N-Aquifer. U.S. Geological Survey Water-Resources Investigations Report 02-4211. Prepared in co-operation with the Arizona Department of Water Resources and Bureau of Indian Affairs.

This page intentionally left blank

ATTACHMENT A

HYDROGRAPHS

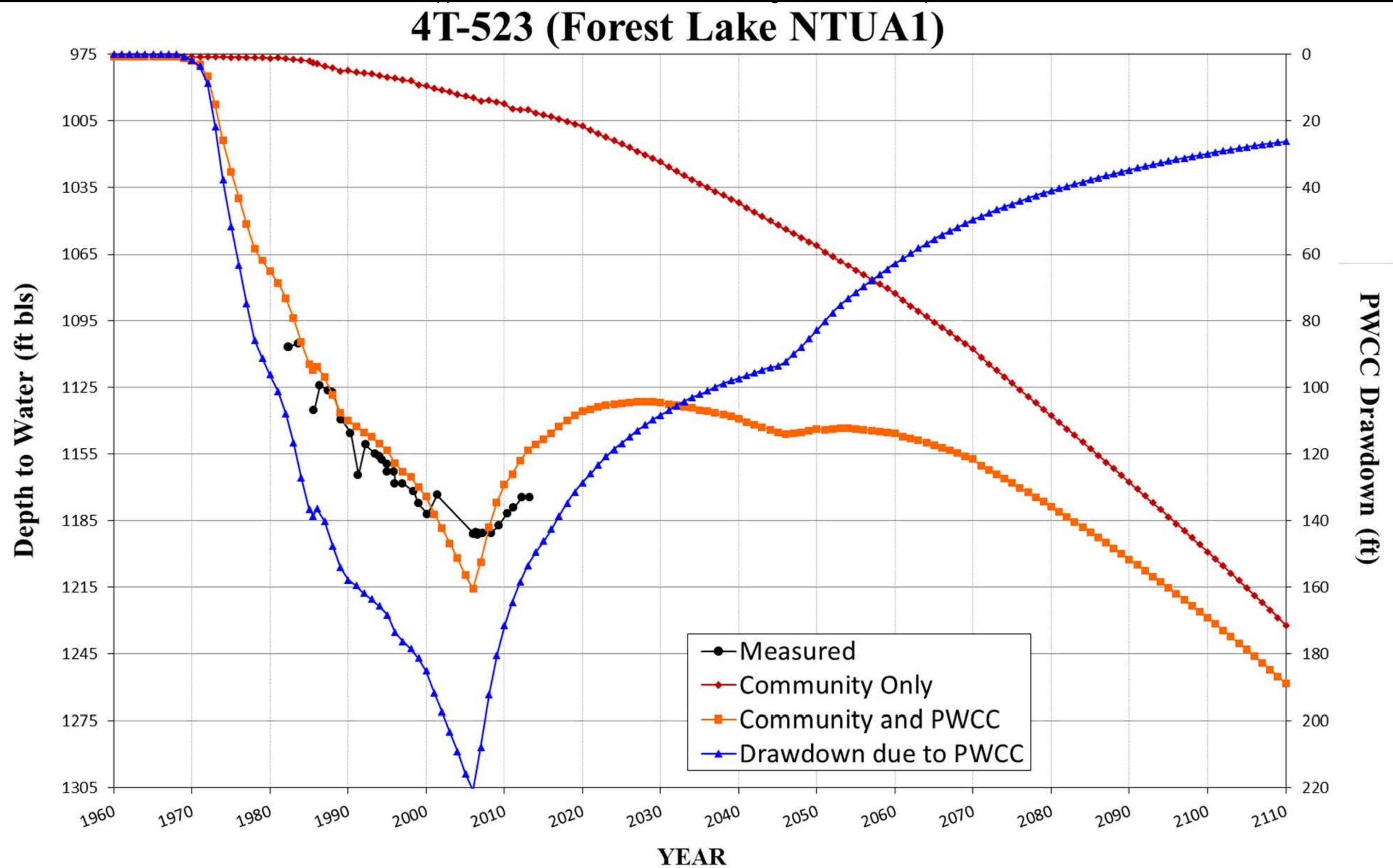
This page intentionally left blank



HYDROGRAPH WELL LOCATIONS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.1

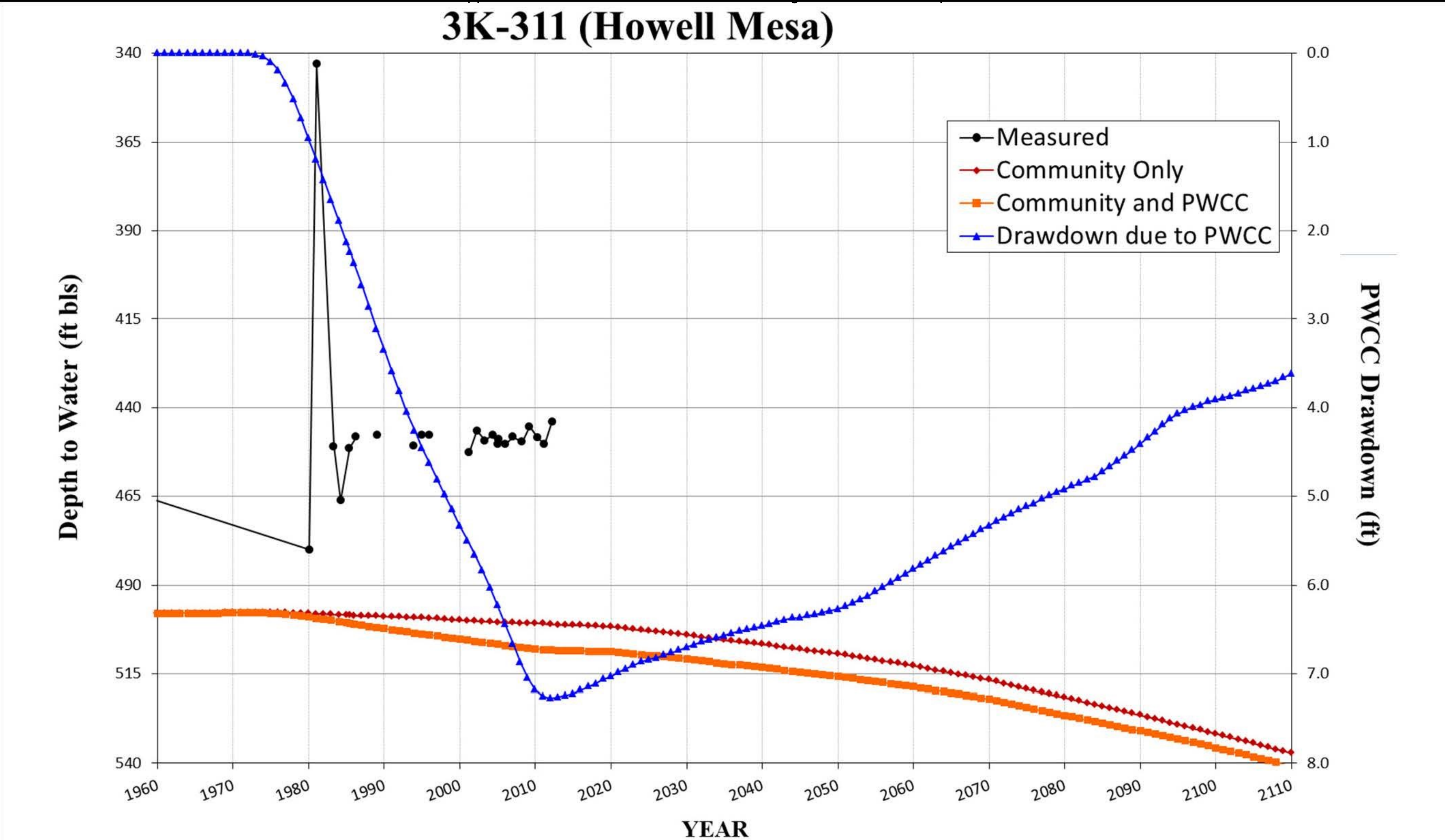


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.2

3/30/16

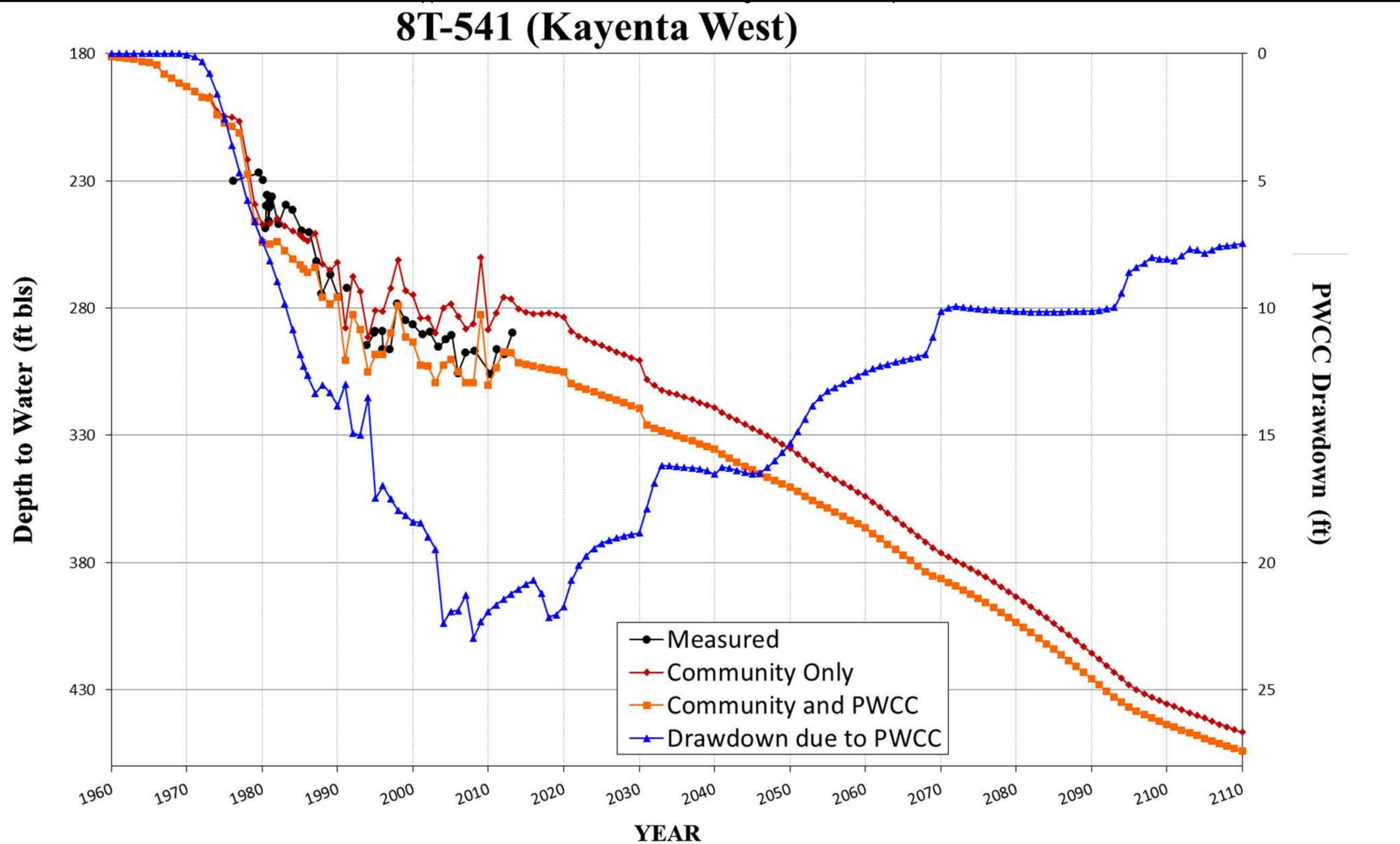


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.3

3/30/16

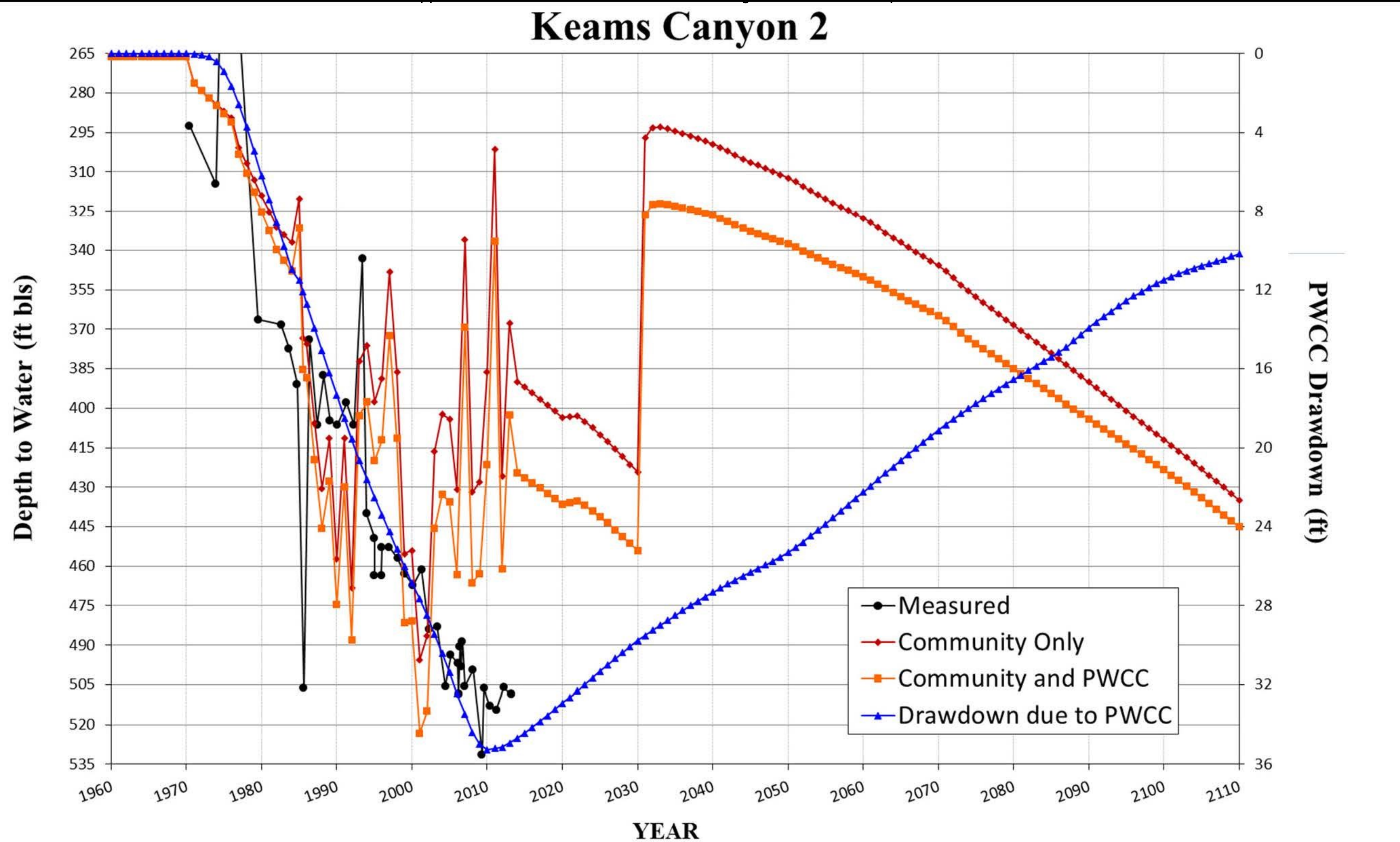


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.4

3/30/16

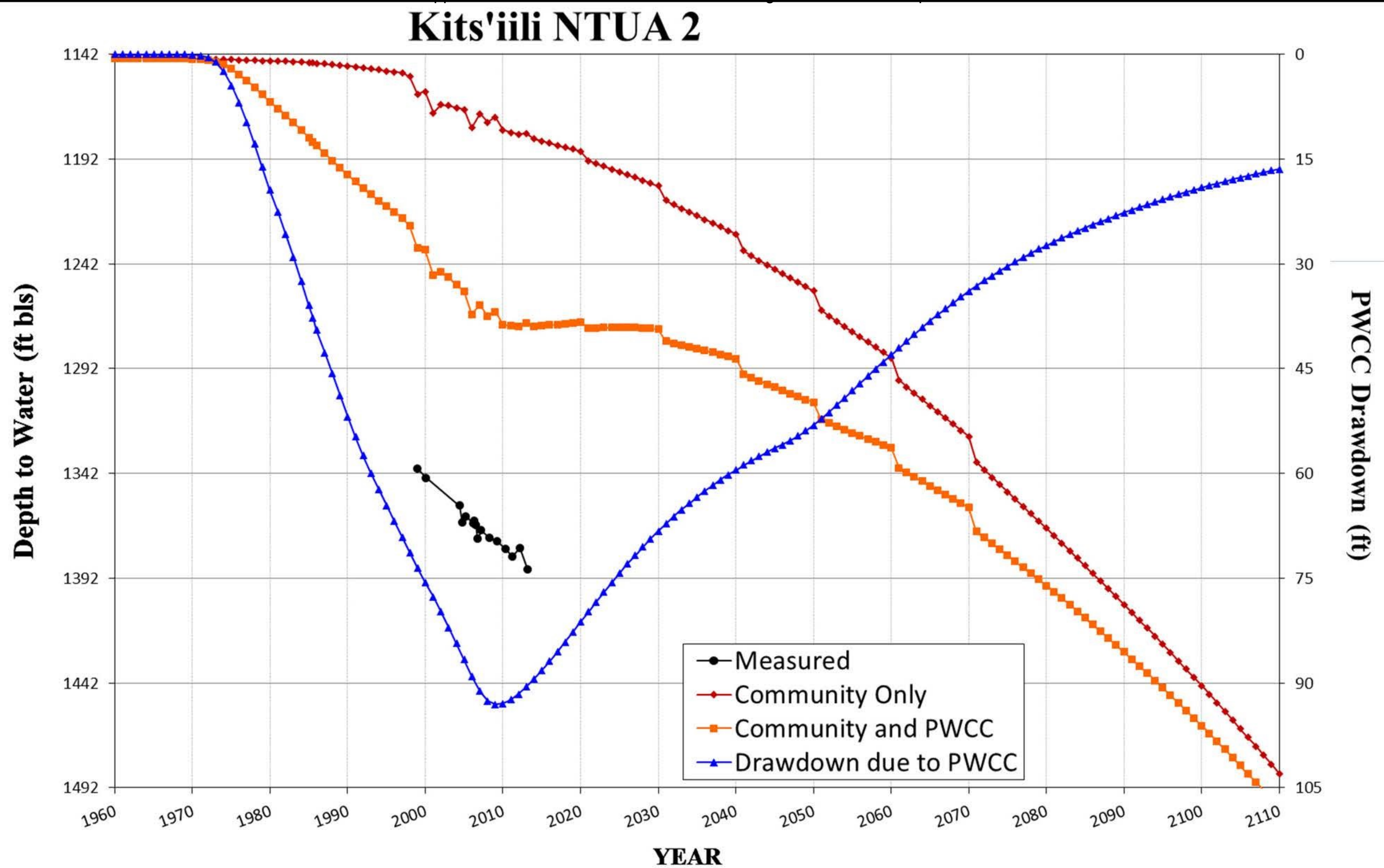


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.5

3/30/16

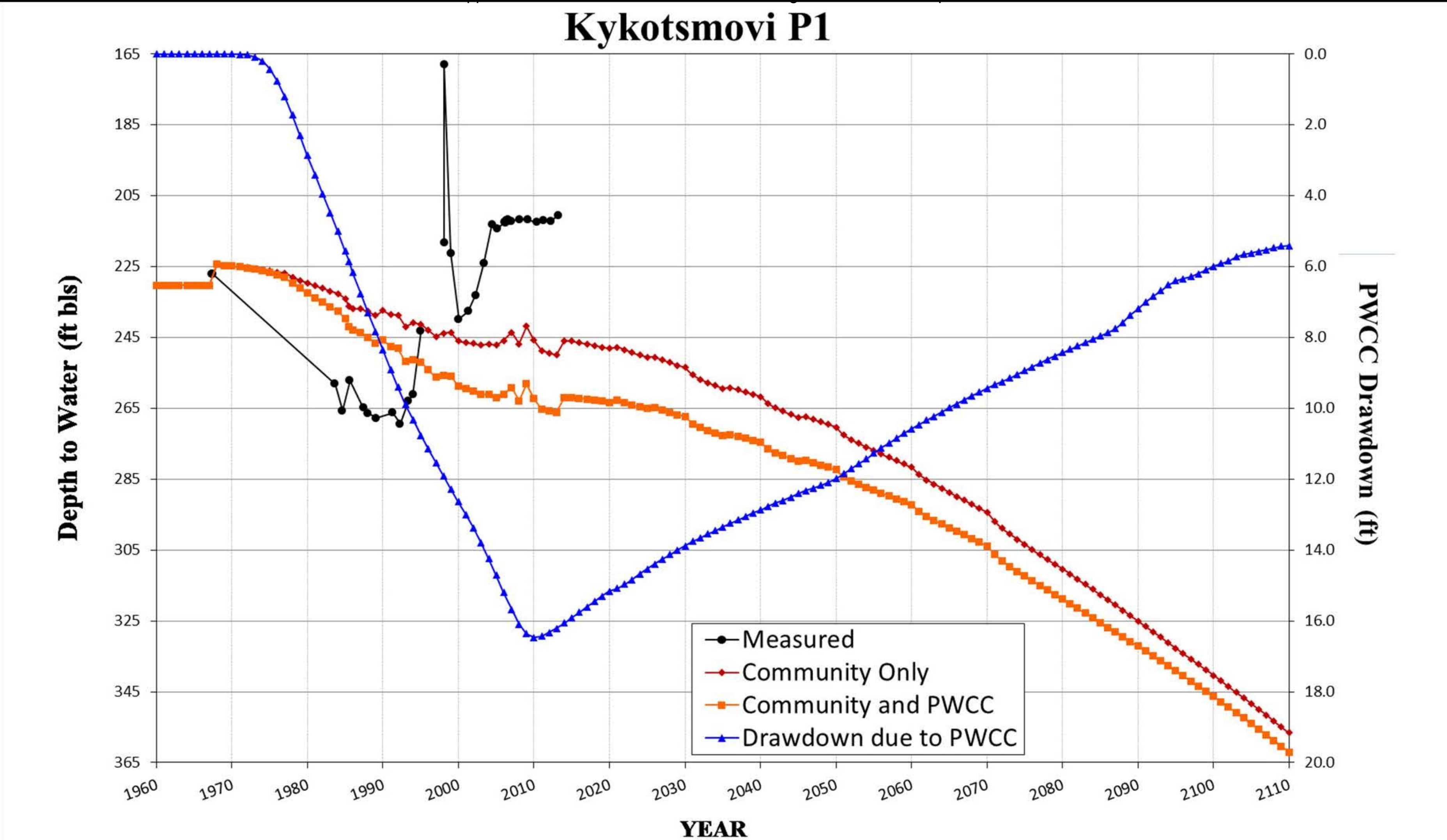


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.6

3/30/16

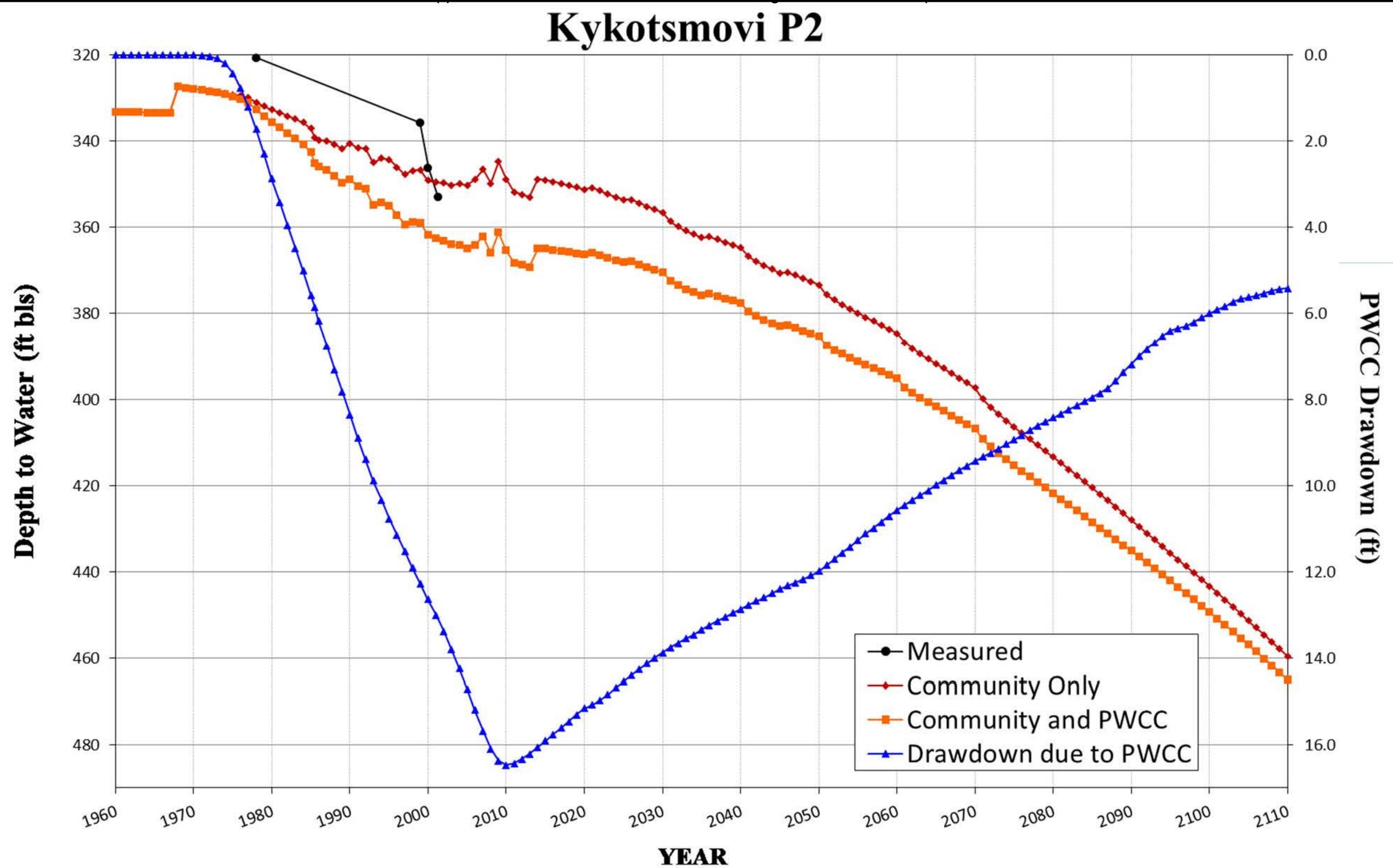


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.7

3/30/16

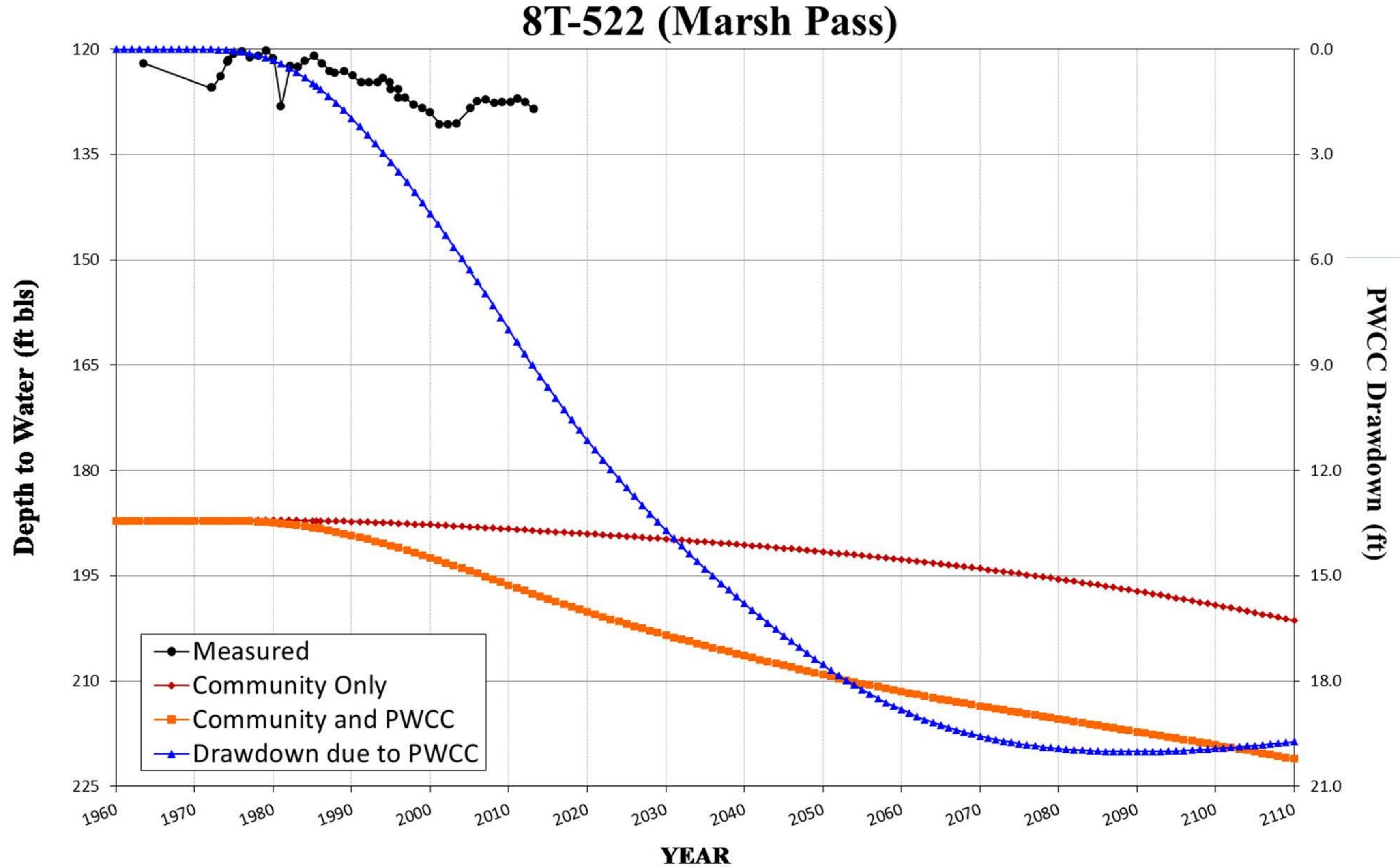


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.8

3/30/16



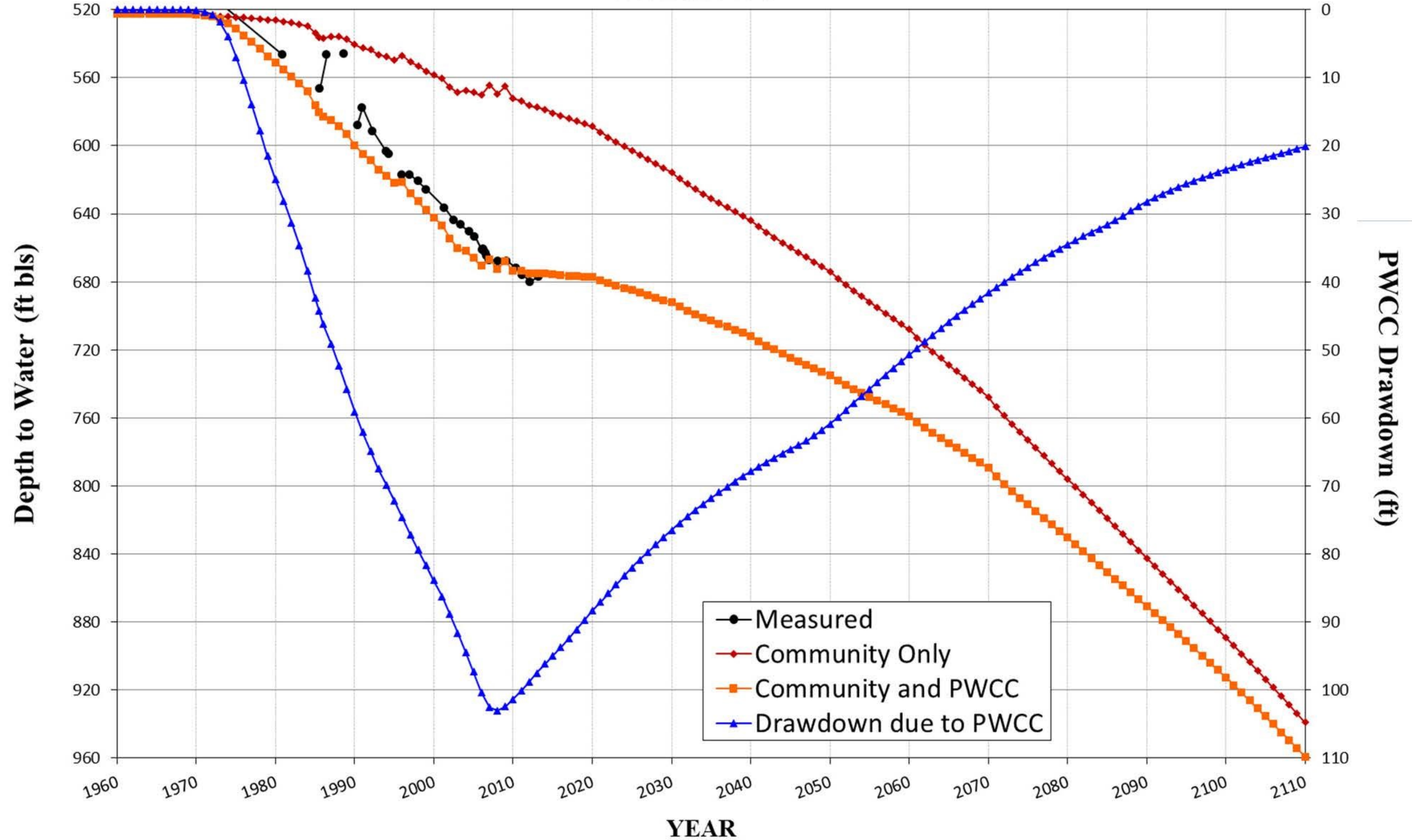
N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.9

3/30/16

Piñon P6

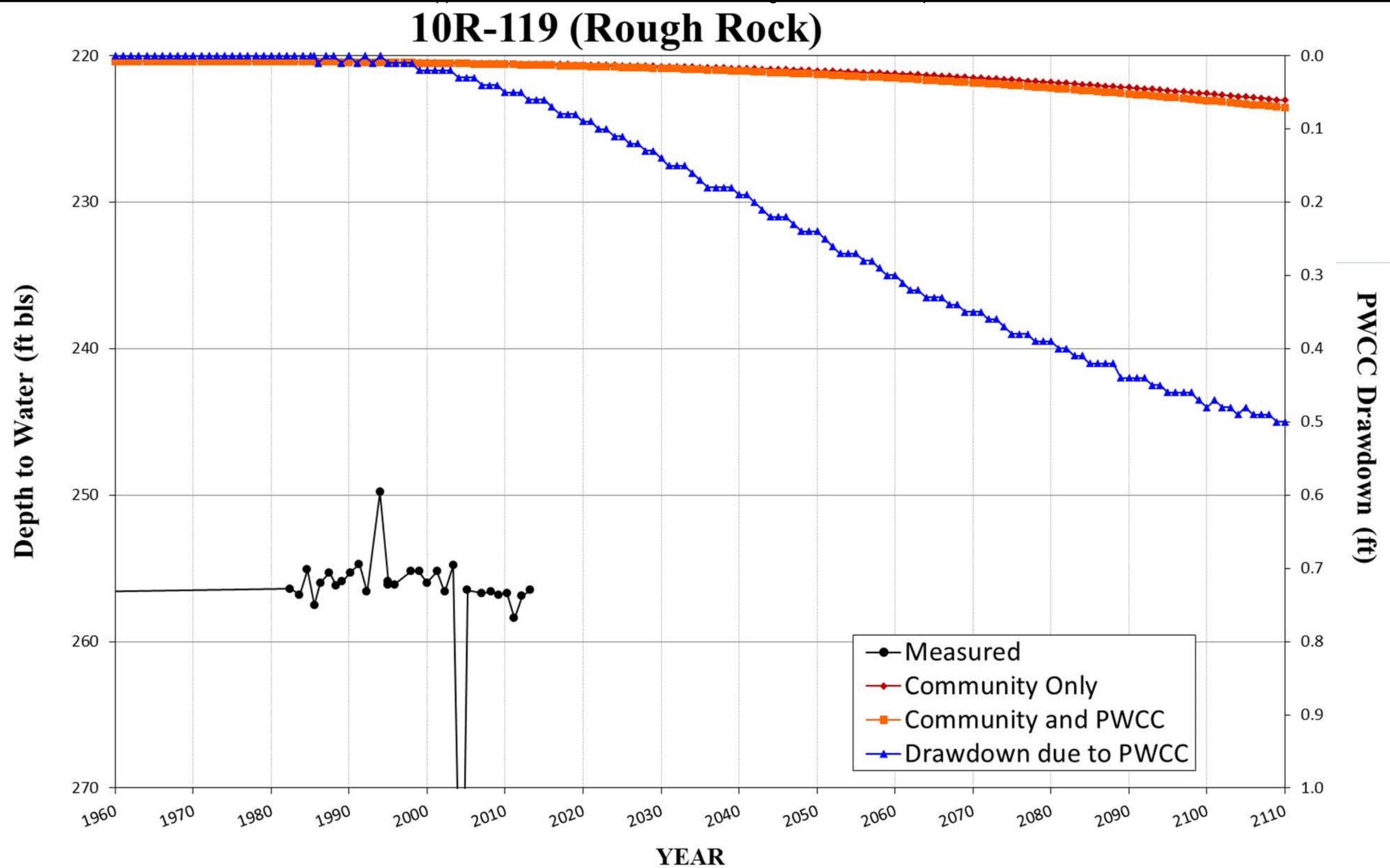


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.10

3/30/16

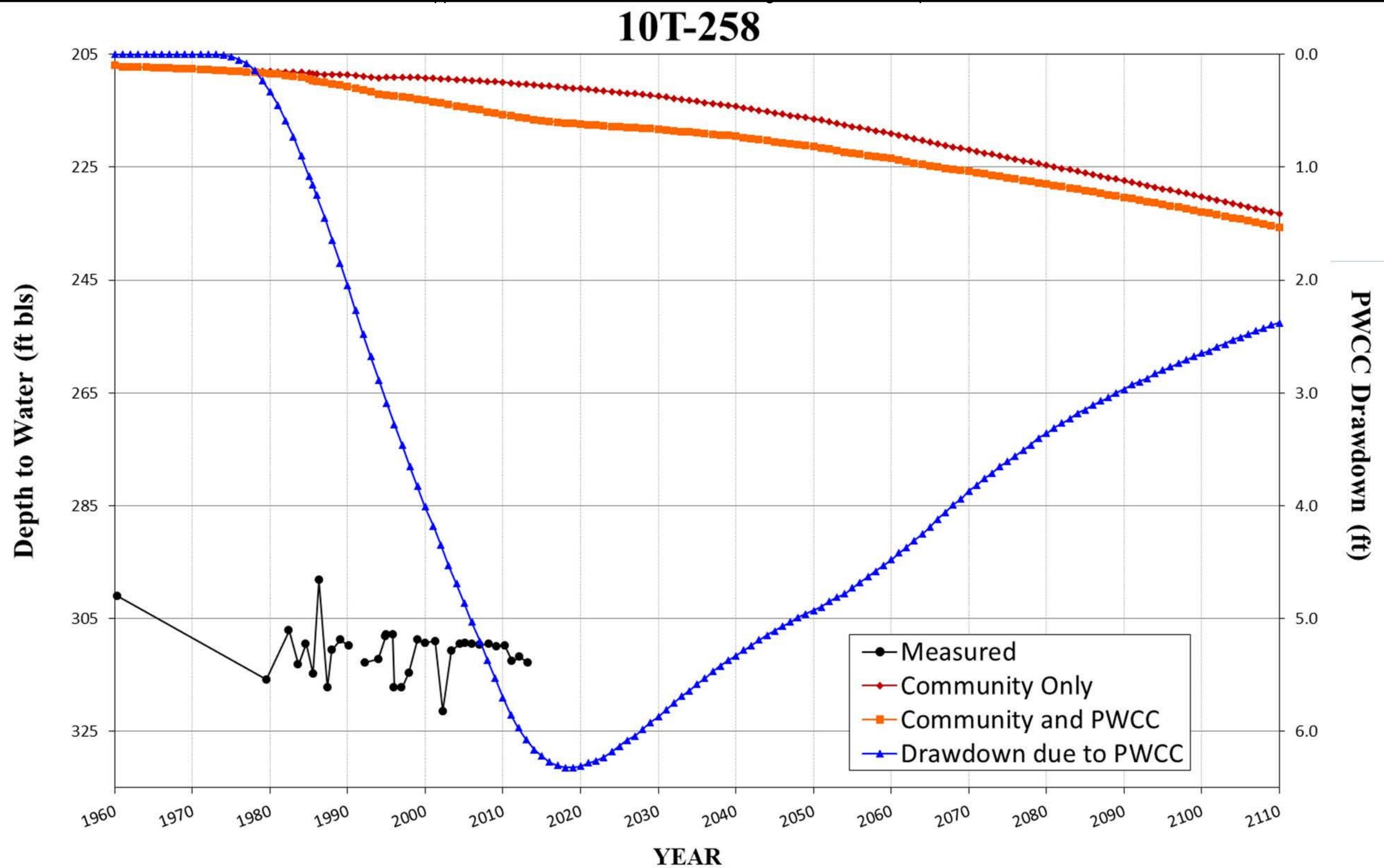


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.11

3/30/16

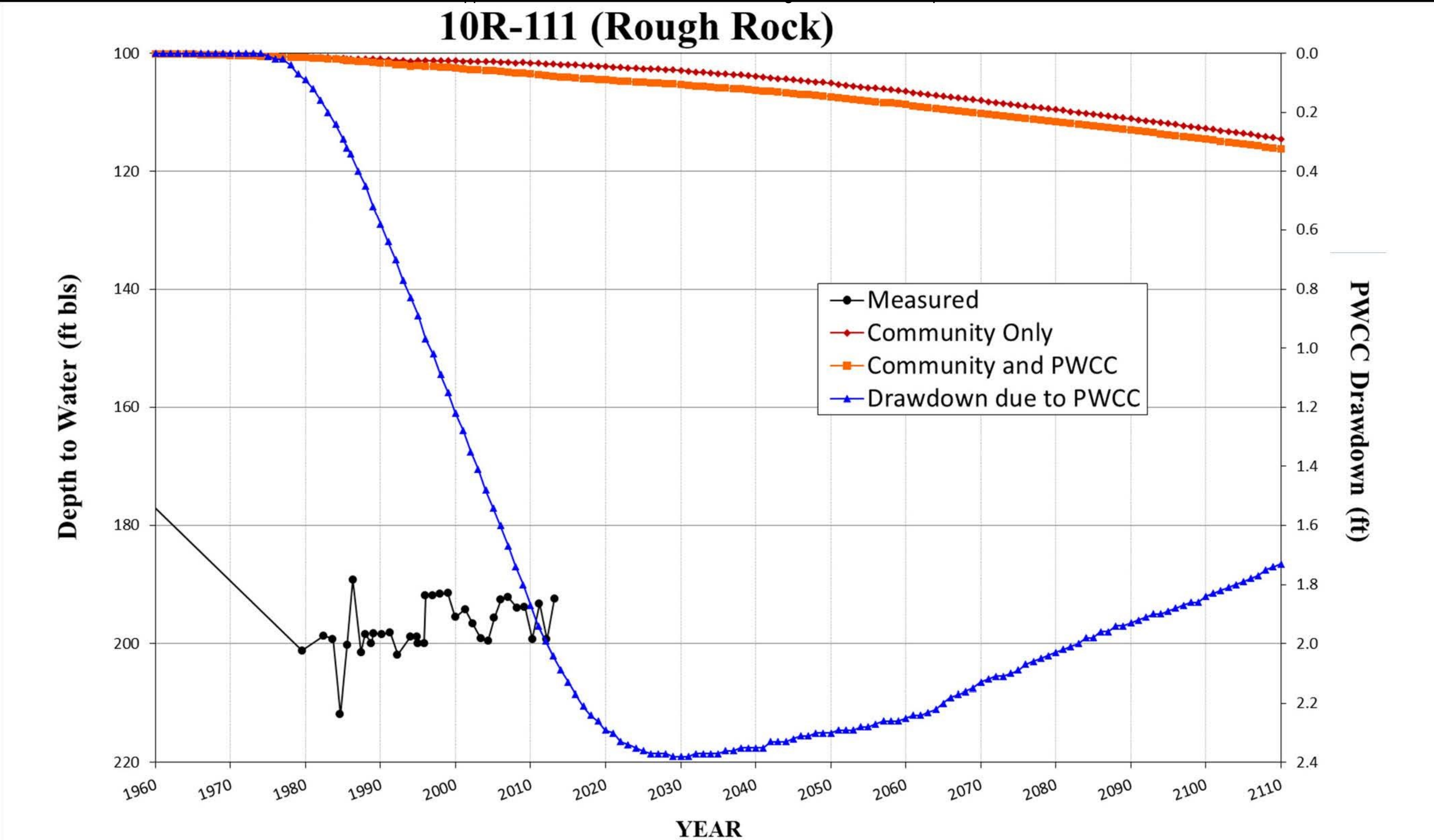


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.12

3/30/16

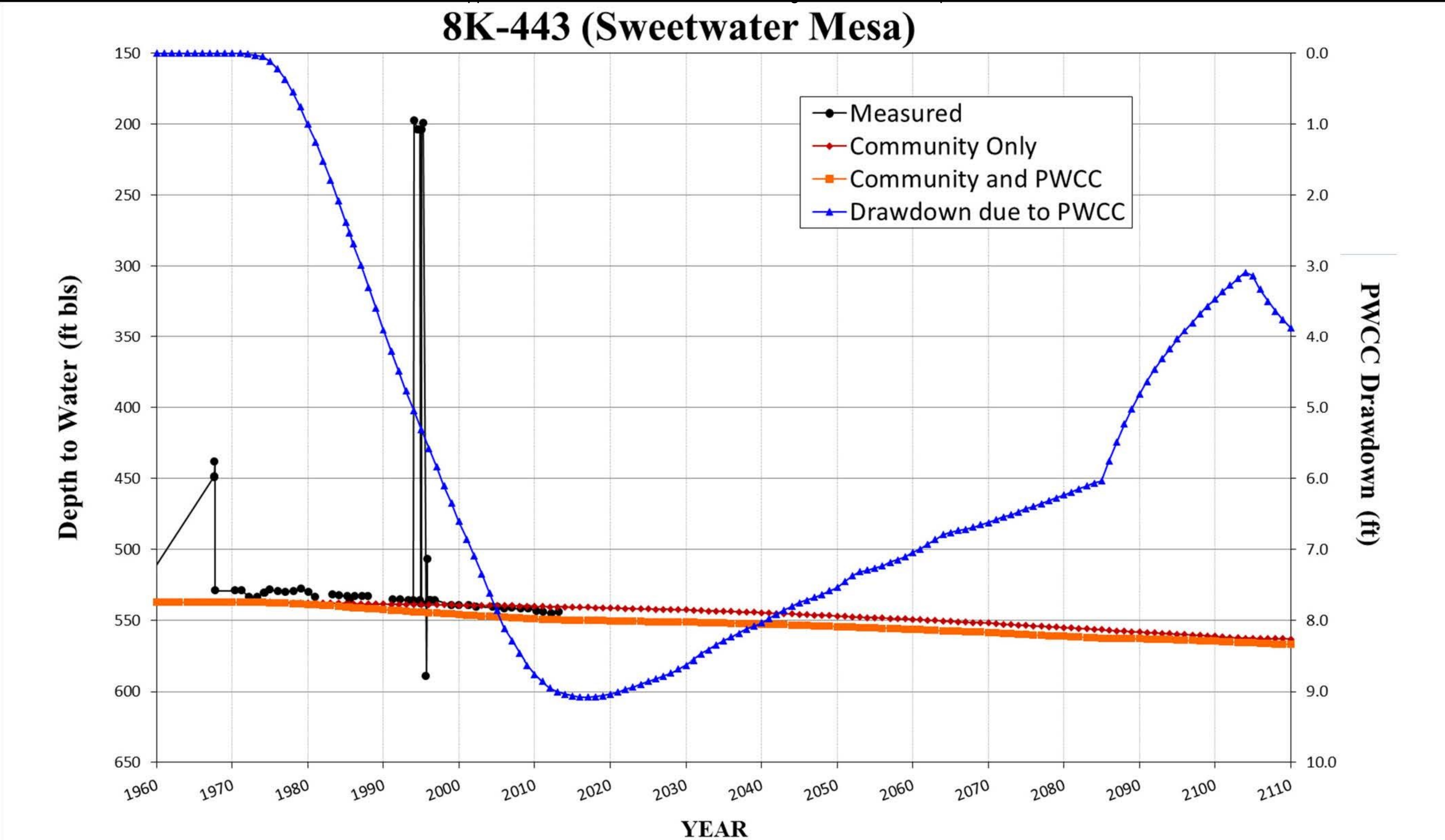


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.13

3/30/16

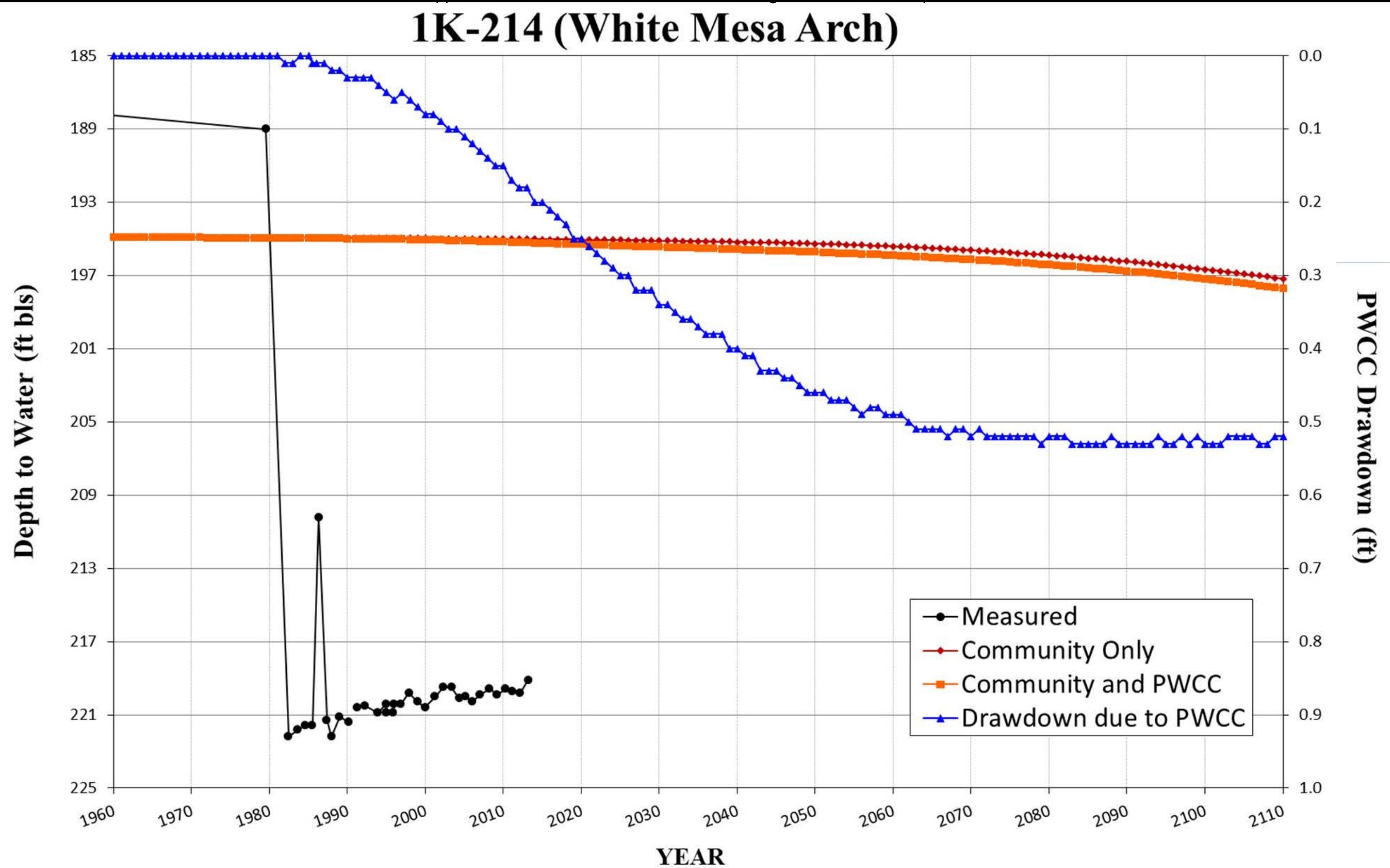


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.14

3/30/16

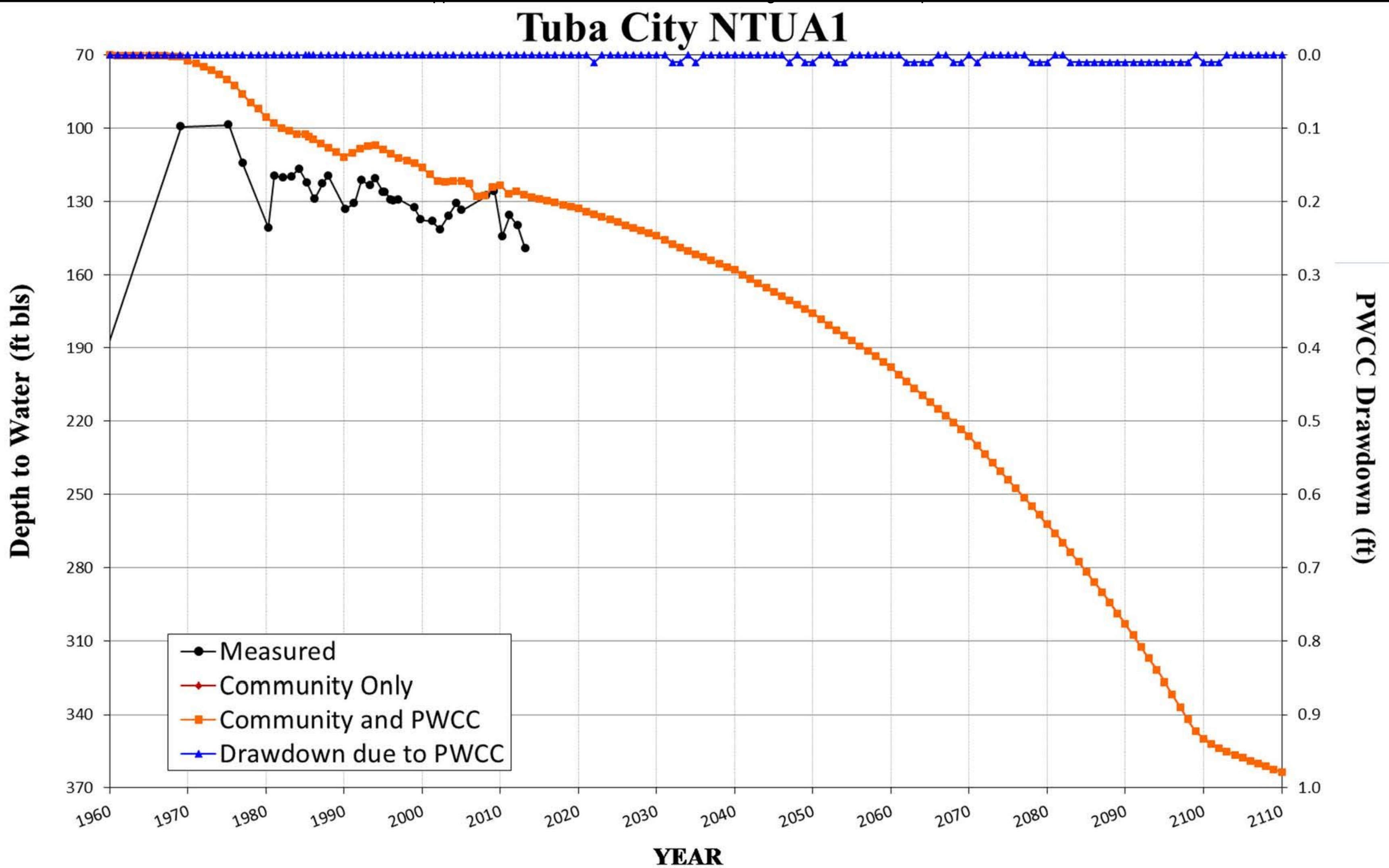


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.15

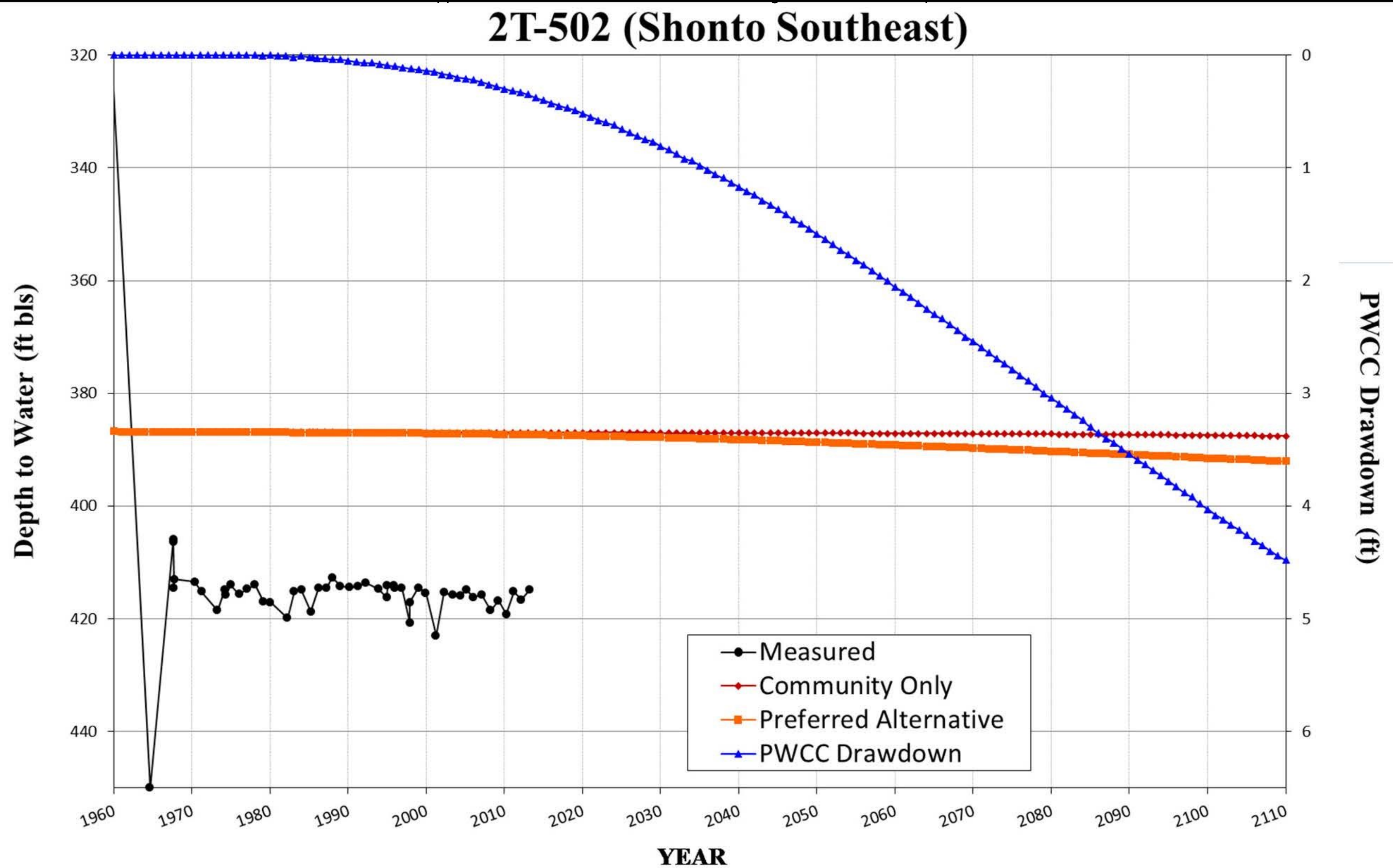
3/30/16



N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.16

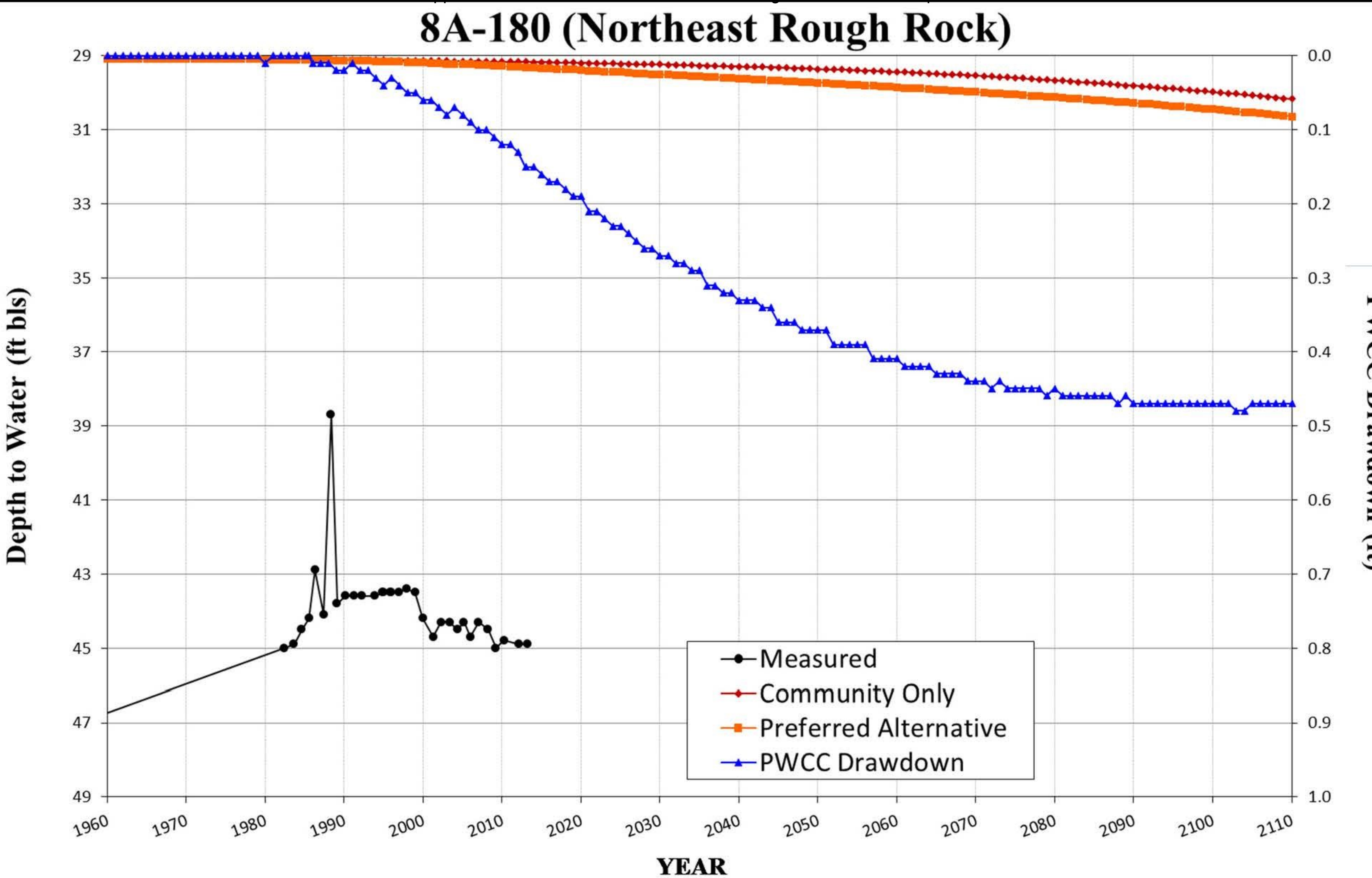


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.17

3/30/16

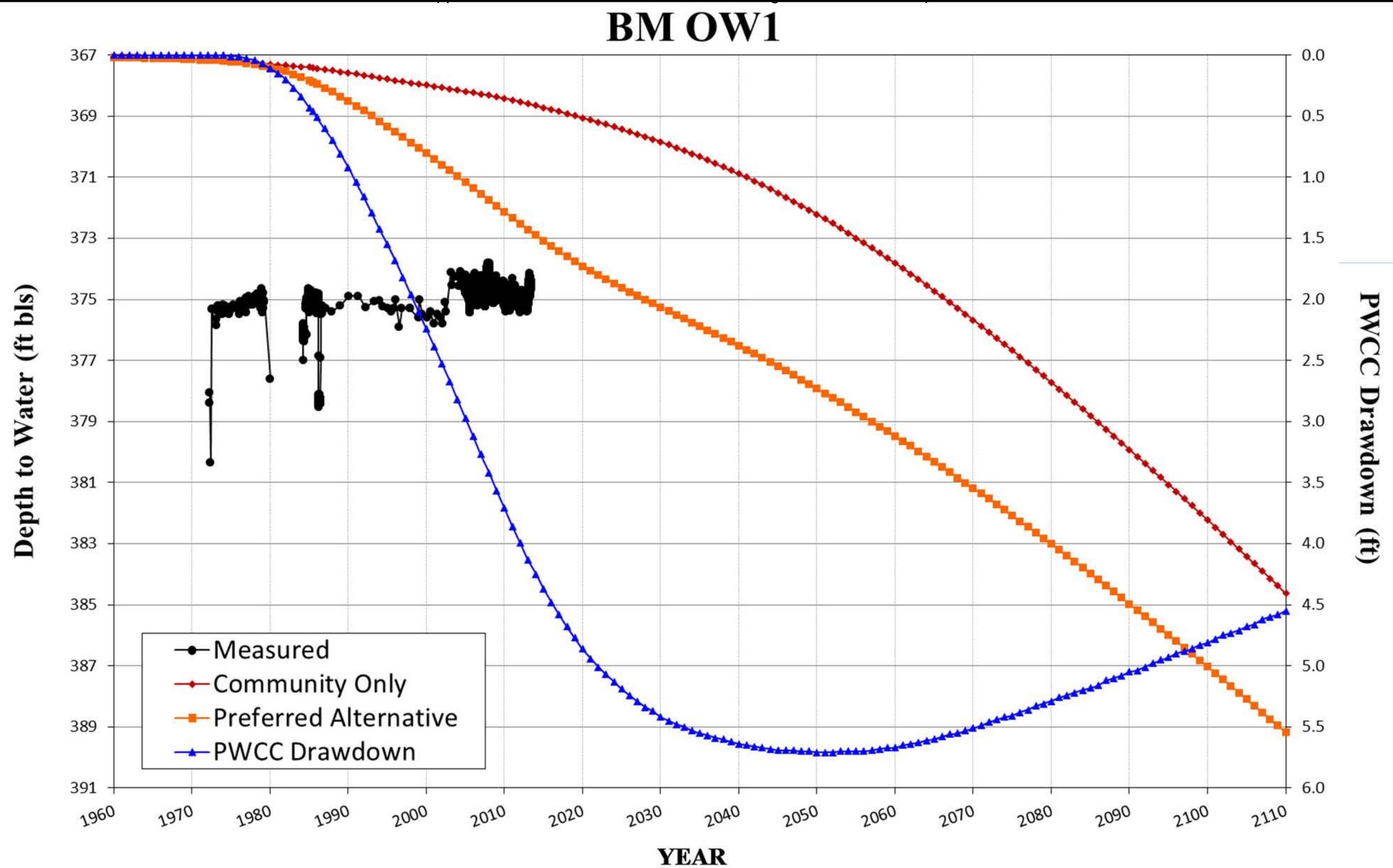


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.18

3/30/16

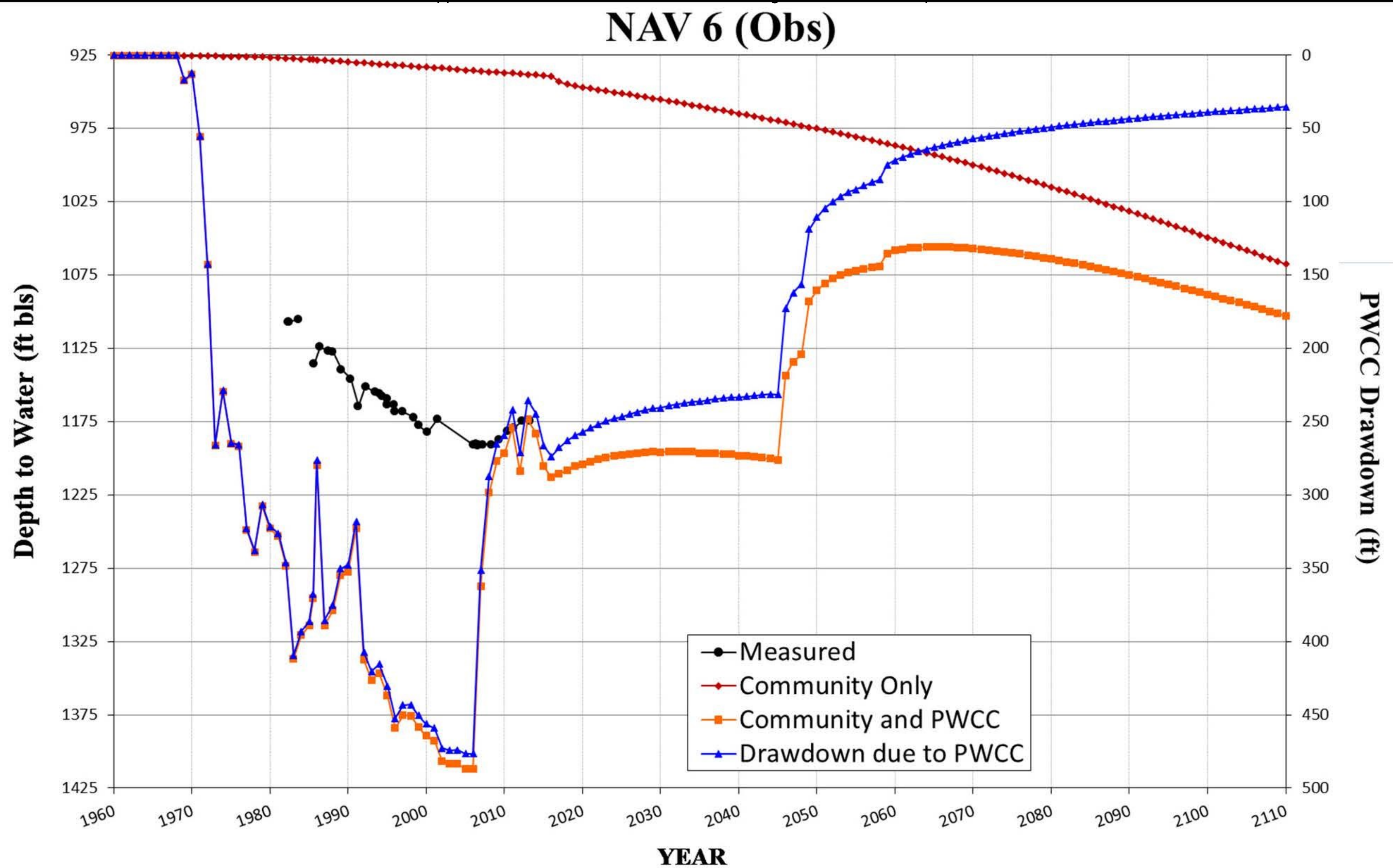


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.19

3/30/16

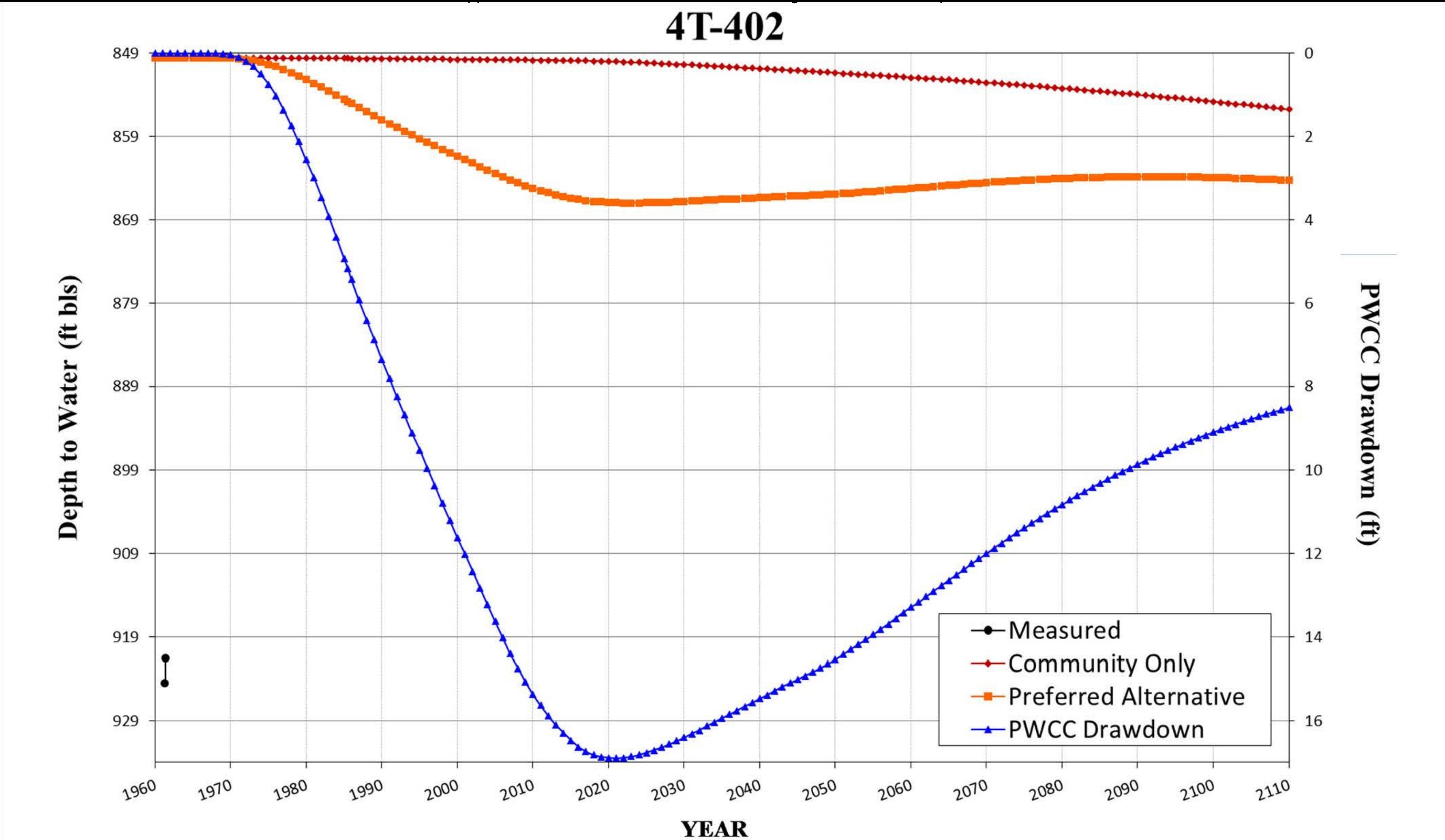


N-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.20

3/30/16

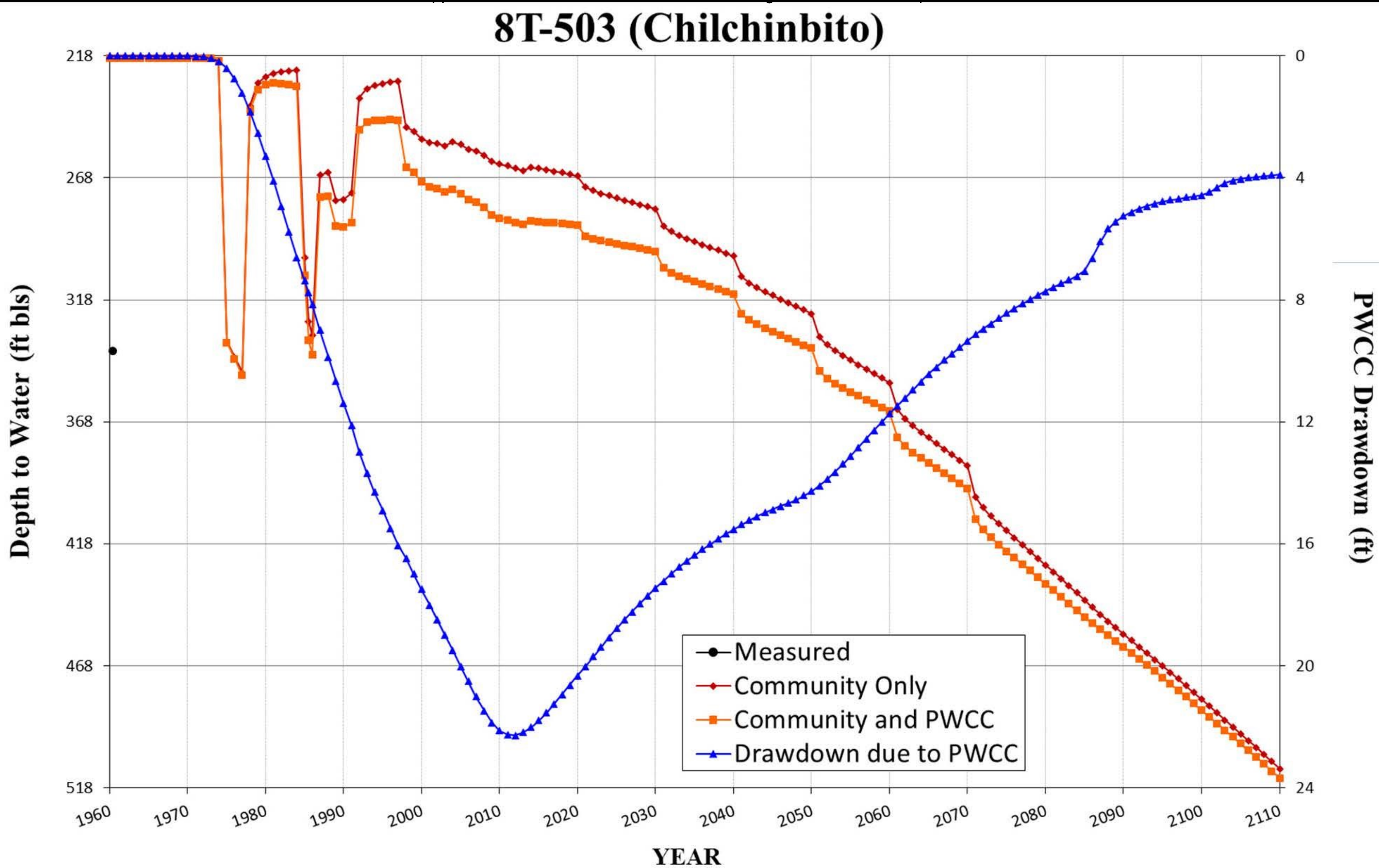


D-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.21

3/30/16

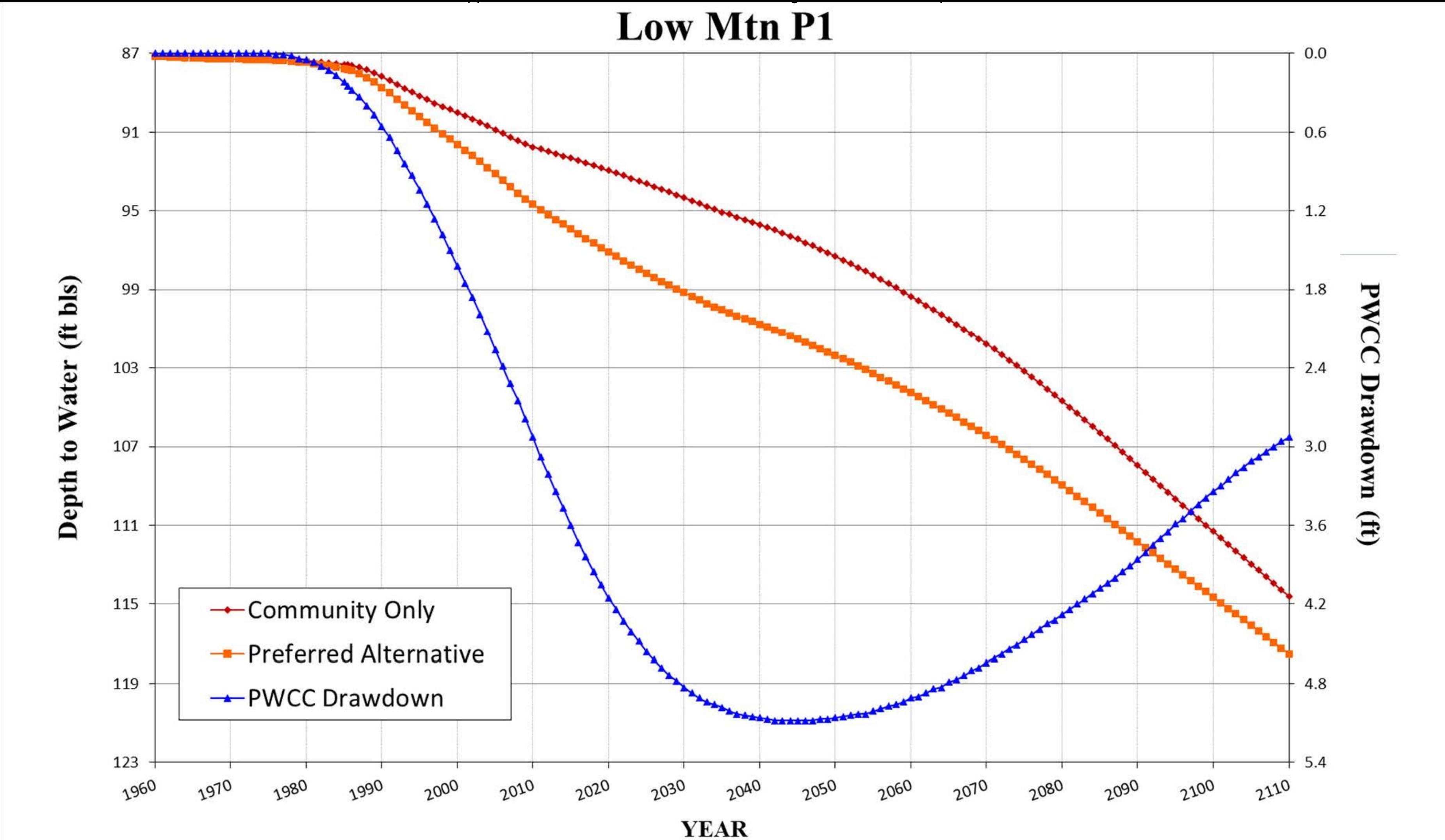


D-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.22

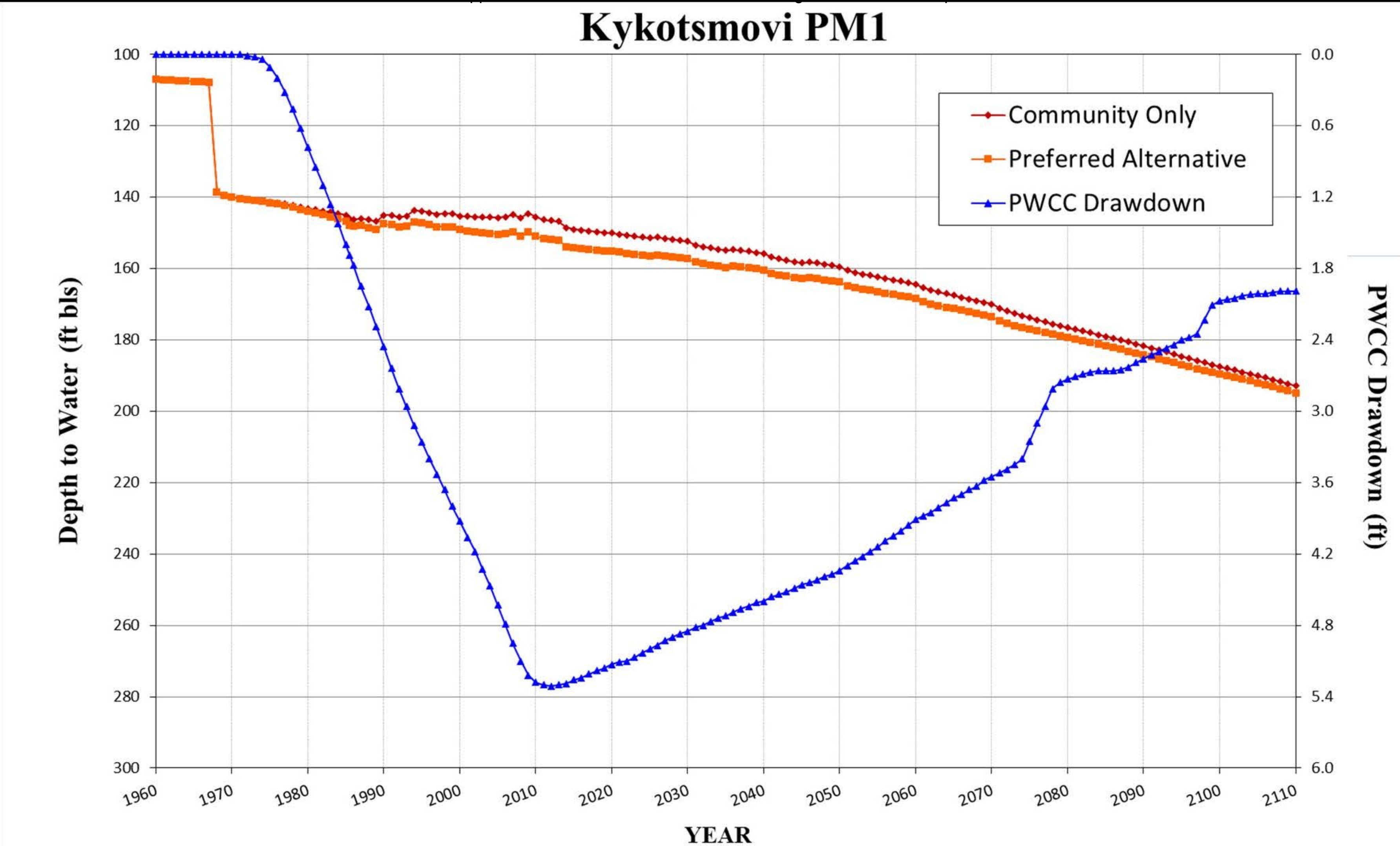
3/30/16



D-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.23

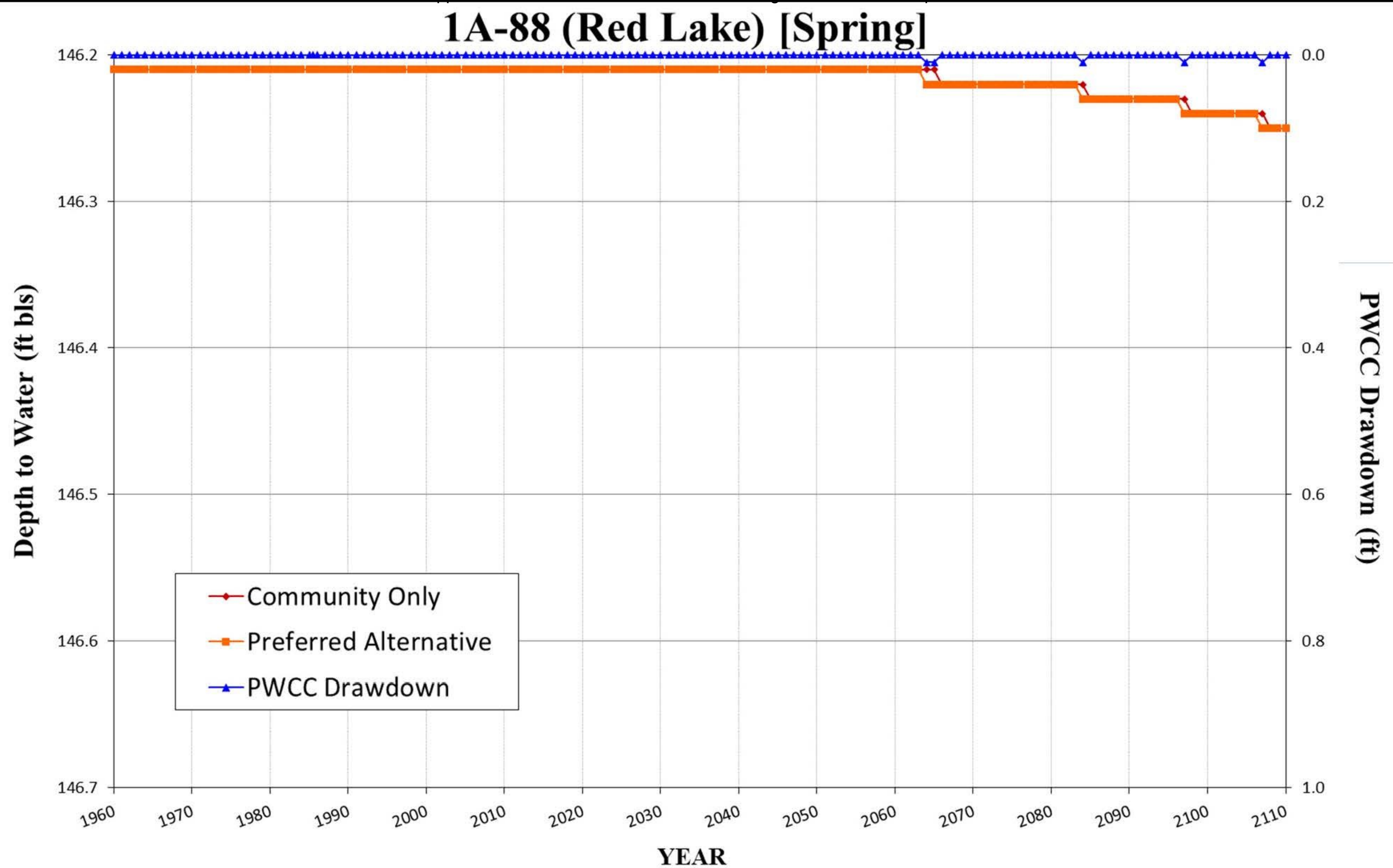


D-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.24

3/30/16



D-AQUIFER HYDROGRAPHS

Navajo Generating Station and Proposed Kayenta Mine Complex EIS

Figure WR-9A.25

3/30/16

This page intentionally left blank

Appendix WR-10

U.S. Geological Survey Project Report

This page intentionally left blank

Hydrologic Analyses In Support of the Navajo Generating Station-Kayenta Mine Complex Environmental Impact Statement

Open-File Report 2016–1088

U.S. Department of the Interior
U.S. Geological Survey

Hydrologic Analyses In Support of the Navajo Generating Station-Kayenta Mine Complex Environmental Impact Statement

By Stanley A. Leake, Jamie P. Macy, and Margot Truini

Open-File Report 2016–1088

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Director

U.S. Geological Survey, Reston, Virginia: 2016

Suggested citation:
Leake, S.A., Macy, J.P., and Truini, Margot, 2016, Hydrologic analyses in support of the Navajo Generating Station–Kayenta Mine Complex environmental impact statement: U.S. Geological Survey Open-File Report 2016–1088, 23 p., http://dx.doi.org/10.3133/ofr20161088.

ISSN 2331-1258 (online)

Contents

Introduction 1
Purpose and Scope 2
Study Area..2
Inventory of Discharge Locations in D and N Aquifers 3
Approach..3
Explanation for Spring Location Attributes 3
Explanation for Spring Terrain Attributes 3
Explanation for Spring Activity Attributes 4
Spring Inventory Results 4
Evaluation of Available Groundwater Models for the N and D Aquifers in the Study Area 4
General Comments on Evaluated Models 5
Comparison of Model-Calculated Steady-State Water Budgets..5
Evaluation of the Technical Design and Calibration of Model Most Appropriate for use by the EIS Team 6
MODFLOW Version Used..6
Model Grid..6
Time Discretization 7
Recharge..7
Other Boundary Conditions..8
Aquifer Storage Properties and Hydraulic Diffusivity 11
Model Calibration..11
Evaluation of Appropriate Post-Pumping Period for Analyses of Long-Term Aquifer Effects 13
Extended-Pumping Analysis 13
Limited-Pumping Analysis..13
Evaluation of Water Quality 16
Summary and Conclusions..17
References Cited 21
Appendix. U.S. Geological Survey Black Mesa Monitoring Reports..23

Figures

1. Study area with extents of groundwater models. The Western Navajo Hopi N aquifer model extends over the area of the N aquifer shown here 2
2. Comparison of N aquifer steady-state water budgets from the Peabody Western Coal Company, U.S. Geological Survey, and Western Navajo Hopi N aquifer models 6
3. Distribtion of recharge from precipitation simulated in the Peabody Western Coal Company model 8
4. Distribution of 1940-2008 average recharge from precipitation calculated by Basin Characterization Model 9
5. Yearly basin characterization model recharge in the Peabody Western Coal Company active model area and precipitation at Tuba City, 1940-2008 9
6. Capture results for the Extended-Pumping Analysis using the Peabody Western Coal Company model....14
7. Capture results for the Extended-Pumping Analysis using the U.S. Geological Survey model 14
8. Comparison of global capture computed by the Peabody Western Coal Company and U.S. Geological Survey models for the Extended-Pumping Analysis....15
9. Comparison of global capture computed by the Peabody Western Coal Company and U.S. Geological Survey models for the limited-pumping analysis 15
10. Fraction of the ultimate global caoture volume computed by the Peabody Western Coal Company model for the limited-pumping analysis 16
11. Thickness of the Carmel Formation, ranges of natural gamma and electrical conductivity from borehole-geophysical logs, and relative $^{87}Sr/^{86}Sr$ signatures, Black Mesa, Arizona....18
12. Concentrations of dissolved solids, chloride, and sulfate for water samples from Burro Spring, 1982–2013 19

Tables

1. Types of artificial boundaries commonly used to limit the extents of the simulated domains in models of groundwater flow....10
2. Arithmetic averages of select aquifer properties within a 20,000-foot radius of well NAV 8 12
3. Site name and U.S. Geological Survey site ID for wells and springs with a minimum of 5 years of total dissolved solids, chloride, and sulfate water-chemistry data 20

Hydrologic Analyses In Support of the Navajo Generating Station-Kayenta Mine Complex Environmental Impact Statement

By Stanley A. Leake, Jamie P. Macy, and Margot Truini

Introduction

The U.S. Department of Interior's Bureau of Reclamation, Lower Colorado Region (Reclamation) is preparing an environmental impact statement (EIS) for the Navajo Generating Station-Kayenta Mine Complex Project (NGS-KMC Project). The proposed project involves various Federal approvals that would facilitate continued operation of the Navajo Generating Station (NGS) from December 23, 2019 through 2044, and continued operation of the Kayenta Mine and support facilities (collectively called the Kayenta Mine Complex, or KMC) to supply coal to the NGS for this operational period. The EIS will consider several project alternatives that are likely to produce different effects on the Navajo (N) aquifer; the N aquifer is the principal water resource in the Black Mesa area used by the Navajo Nation, Hopi Tribe, and Peabody Western Coal Company (PWCC).

The N aquifer is composed of three hydraulically connected formations—the Navajo Sandstone, the Kayenta Formation, and the Lukachukai Member of the Wingate Sandstone—that function as a single aquifer. The N aquifer is confined under most of Black Mesa, and the overlying stratigraphy limits recharge to this part of the aquifer. The N aquifer is unconfined in areas surrounding Black Mesa, and most recharge occurs where the Navajo Sandstone is exposed in the area near Shonto, Arizona (Lopes and Hoffmann, 1997). Overlying the N aquifer is the D aquifer, which includes the Dakota Sandstone, Morrison Formation, Entrada Sandstone, and Carmel Formation. The aquifer is named for the Dakota Sandstone, which is the primary water-bearing unit (Cooley and others, 1969).

The NGS is located near Page, Arizona on the Navajo Nation. The KMC, which delivers coal to NGS by way of a dedicated electric railroad, is located approximately 83 miles southeast of NGS (about 125 miles northeast of Flagstaff, Arizona). The Kayenta Mine permit area is located on about 44,073 acres of land leased within the boundaries of the Hopi and Navajo Indian Reservations. KMC has been conducting mining and reclamation operations within the Kayenta Mine permit boundary since 1973.

The KMC part of the proposed project requires approval by the Office of Surface Mining (OSM) of a significant revision of the mine's permit to operate in accordance with the Surface Mine Control and Reclamation Act (Public Law 95-87, 91 Stat. 445 [30 U.S.C. *1201 et seq.*]). The revision will identify coal resource areas that may be used to continue extracting coal at the present rate of approximately 8.2 million tons per year. The Kayenta Mine Complex uses water pumped from the D and N aquifers beneath PWCC's leasehold to support mining and reclamation activities. Prior to 2006, water from the PWCC well field also was used to transport coal by way of a coal-slurry pipeline to the now-closed Mohave Generating Station. Water usage at the leasehold was approximately 4,100 acre-feet per year (acre-ft/yr) during the period the pipeline was in use, and declined to an average 1,255 acre-ft/yr from 2006 to 2011 (Macy and Unema, 2014). The Probable Hydrologic Consequences (PHC) section of the mining and reclamation permit must be modified to project the consequences of extended water use by the mine for the duration of the KMC part of the project, including a post-mining reclamation period.

Since 1971, the U.S. Geological Survey (USGS) has conducted the Black Mesa Monitoring Program, which consists of monitoring water levels and water quality in the N aquifer, compiling information on water use by PWCC and tribal communities, maintaining several stream-gaging stations, measuring discharge at selected springs, conducting special studies, and reporting findings. These data are useful in evaluating the effects on the N aquifer from PWCC and community pumping, and the effects of variable precipitation.

The EIS will assess the impacts of continued pumping on the N aquifer, including changes in storage, water quality, and effects on spring and baseflow discharge, by proposed mining through 2044, and during the reclamation process to 2057.

Several groundwater models exist for the area and Reclamation concluded it would conduct a peer review of the groundwater flow model that will be used to assess the direct, reasonably foreseeable indirect, and cumulative effects of future groundwater withdrawals on the D and N aquifers in the Black Mesa area. Reclamation made this determination because of the level of controversy around the effects of continued water use and the comments received from the 2014 draft EIS scoping meetings. Reclamation requested assistance from the USGS in evaluating existing groundwater flow models of the Black Mesa Basin that can be used to predict the effects of different project alternatives on the D and N aquifers.

Purpose and Scope

The purpose and scope of these hydrologic analyses include tasks (1) performing an inventory of discharge locations (springs and perennial stream reaches) in the D and N aquifers; (2) evaluation of D and N aquifer groundwater models that could meet the needs of the NGS-KMC EIS; (3) evaluation of the technical design and calibration of the model that is most appropriate for use for the EIS; (4) evaluation of appropriate post-pumping periods for analyses of long-term aquifer effects; (5) evaluation of model projections; and (6) evaluation of existing USGS water-quality data for the Black Mesa area to quantify historical changes in water quality caused by pumping and recovery. This report outlines the results of USGS investigations for items 1–4 and 6. Model projections for item 5 were not available when this report was being prepared and will not be included in this report. Information from these analyses will be used by Reclamation in the preparation of the EIS.

Study Area

The study area is located in northeastern Arizona and contains diverse topography such as flat plains, mesas, and incised drainages. Black Mesa, a topographic high at the center of the study area encompasses about 2,000 square miles (mi^2) (fig. 1). Black Mesa has 2,000-foot-high cliffs on its northern and northeastern sides, with more gradual slopes to the south and southwest, all of which is included in the study area. For the purposes of groundwater model evaluations, spring inventories, and water-quality analyses, the area within the HDR engineering consulting firm Western Navajo Hopi N Aquifer (WNHN) groundwater model boundary was used as the largest extent of the study area and is referred to as the cumulative effects study area (CESA).

Figure 1. Study area with extents of groundwater models. The Western Navajo Hopi N aquifer (WNHN) model extends over the area of the N aquifer shown here.

Inventory of Discharge Locations in D and N Aquifers

Approach

D and N aquifer discharge locations, more commonly referred to as springs and perennial stream reaches, were inventoried as part of the USGS scope of work for the Navajo Generating Station-Kayenta Mine Complex EIS. Spring and discharge location information was retrieved from the USGS groundwater site-inventory system (GWSI) database. Spring names, locations, and contributing aquifer information were retrieved from the GWSI database using the geographic area defined by the PWCC groundwater model boundary (fig. 1) constructed by Tetra Tech. Springs that did not have contributing aquifer information in GWSI were plotted on geologic maps and, where possible, the contributing aquifer or geologic unit was identified.

In addition to springs in the GWSI database, Tetra Tech developed a separate spring dataset and provided that information to the USGS as an Excel spreadsheet. Tetra Tech's spring dataset was incorporated into the USGS spring inventory as part of Task 1, but these springs were not added to the USGS GWSI database.

After identifying D and N aquifer springs within the PWCC groundwater model in both the USGS GWSI database and in the spring dataset provided by Tetra Tech, the USGS was asked by the Bureau of Reclamation to enlarge the study area boundary to include the HDR groundwater study boundary defined by the extent of the HDR WNHN model boundary (fig. 1). All of the spring data for this larger area were compiled from GWSI in an Excel spreadsheet and plotted in ArcGIS 10.3 for visual display and further analysis.

The spring inventory consisted of identifying spring locations, the terrain surrounding each spring, and spring activity. A spring's location was designated by latitude and longitude information from the USGS GWSI database and the dataset provided by Tetra Tech and plotted in ArcGIS. The plotted springs were compared with topographic maps and aerial photography to determine if the latitude and longitude data were correct. Topographic maps used for the analysis were USGS 1:24,000, 7.5 minute quadrangle series maps. Aerial photography used for the analysis was from the Department of Agriculture National Agriculture Imagery Program (NAIP), which consists of 1-meter resolution imagery for the entire conterminous United States and is acquired as a four-band product that can be viewed as either a natural color or color infrared image. NAIP imagery from 2010 was used for this inventory. Aerial imagery from Google Earth was also used for comparison to NAIP imagery. A spring's location was determined by the presence of vegetation, found on aerial images, associated with spring sites typical of the southwestern U.S. Infrared images from the NAIP aerial imagery dataset were also used to constrain spring location sites by looking for evidence of spring flow and vegetation. Spring flow often appeared in the infrared images as a distinctly different color than the surrounding ground, and vegetation appeared as a red color. Attributes for describing a spring's location are provided below.

Explanation for Spring Location Attributes

Good - The latitude and longitude data from the USGS GWSI database or Tetra Tech dataset matched topographic maps and aerial photography.
Close - The latitude and longitude data from the USGS GWSI database or Tetra Tech dataset were in close proximity to springs evident on topographic maps or aerial photography.
Bad - The latitude and longitude data from the USGS GWSI database or Tetra Tech dataset were not in the same location as a visible spring on aerial photography or a topographic map. In instances where the location data were bad and a spring was evident on aerial photography, a new revised location was established.
Unknown - The latitude and longitude data from the USGS GWSI database or Tetra Tech dataset were not in an area where a spring was evident on aerial photography or a topographic map.

Once a spring was located the nearby terrain was described using the attributes below. Explanations for spring terrain attributes were determined from personal experience by USGS hydrologists at certain spring locations and from aerial photography.

Explanation for Spring Terrain Attributes

Near_drainage - Spring is near a large wash along the banks or in a meander off of the main channel.
Near_stock_tank – Spring appeared to be flowing into a stock tank or was near a stock tank.
Surrounded_by_desert – Spring is surrounded by sand/sediment and sometimes small shrubs. There is no significant bedrock nearby.
In_canyon -Spring is along the bottom of a canyon and discharge to drainage is uncertain, spring is coming up mid-channel or along the edge of the channel.
Near_dwellings – Spring is developed and surrounded by or near modern day dwellings either in a town or one/several homesteads.
In_field_drainage - Spring is near fields alongside a drainage.
On_bedrock – Spring is on and surrounded by bedrock.
Base_of_cliff –Spring is discharging from the base of a cliff.
In_shallow_canyon – Spring is in a channel along a shallow canyon where the walls are not steep or deep.
Near_large_river – Spring plots in a river.

The final attribute for evaluating springs as part of this inventory is the activity of a spring. Spring activity was determined from personal experience by USGS hydrologists at certain spring locations, including discharge measurements, and from aerial photography. Explanations for spring activity attributes are listed below.

Explanation for Spring Activity Attributes

No_apparent_spring – Dry drainage with no upstream sign of water; sitting on bedrock with no green for many miles; desert/bedrock with nothing more than small shrubs or sand with infrared NAIP data not showing very red vegetation.
Unknown – Uncertainty of location and existence of a spring.
Flowing – Spring is clearly flowing and there is little to no vegetation nearby.
Flow_vegetation – Can see flowing water with lots of vegetation.
Seep – Location indicated damp earth with white/discolored mineral precipitation.
Developed – Location showed spring houses/troughs/storage tanks; some were based on previous knowledge of the site from having visited the location.
WWTP – Waste water treatment plant – location was near a WWTP; not always clear if the location was identified correctly because there was an existing body of water.

Spring Inventory Results

The final compilation of information from the spring inventory was provided to the Bureau of Reclamation as a single Excel spreadsheet that detailed the spring location (with revised location information), terrain surrounding the spring, and activity of the spring. Duplicate springs found in the USGS GWSI database and provided by Tetra Tech also were documented. There were 75 springs and discharge locations compiled from the USGS GWSI database and 119 springs provided by Tetra Tech. Six of the springs in the USGS GWSI database were duplicates of springs provided by Tetra Tech. Of the 75 springs found in the USGS database, 15 of those springs have recorded discharge greater than 10 gallons per minute. Discharge measurements made at those 15 springs occurred between 1948 and 2006. There are no measured discharges above 10 gallons per minute after 2006 in the USGS database.

The spring information contained in the final compilation spreadsheet is sensitive water information and is not published as part of this report. Maintaining confidentiality of spring and discharge locations is necessary because they are traditional cultural properties of historical and (or) religious significance to indigenous peoples.

Evaluation of Available Groundwater Models for the N and D Aquifers in the Study Area

The proposed Cumulative Effects Study Area encompasses the area of the N aquifer shown in figure 1. For this area, a groundwater model is needed to evaluate effects of groundwater pumping by the Black Mesa Kayenta Mine Complex, as well as pumping by communities on and around Black Mesa. Nearly all groundwater pumping in the area is from the N aquifer, which is hydraulically connected to the overlying D aquifer. Pumping effects of interest include reduction of groundwater head (drawdown), capture of groundwater outflow by evapotranspiration, capture of groundwater discharge to springs and streams, and depletion of flow in streams (streamflow depletion). Hydrologic features for which pumping effects are to be evaluated occur in both the N and D aquifers.

Three readily available MODFLOW (Harbaugh, 2005; Niswonger and others, 2011) groundwater flow models of the N aquifer exist for all or a major part of the study area. These include the U.S. Geological Survey Black Mesa model of the N aquifer (Brown and Eychaner, 1988), the Western Navajo Hopi N Aquifer model (HDR Engineering, Inc., 2003), and the Peabody Western Coal Company model (Tetra Tech, 2014). The Western Navajo Hopi N Aquifer model and the Peabody Western Coal Company model simulate flow in both the N and D aquifers, as well as in the intervening Carmel Formation (confining unit), whereas the USGS Black Mesa model simulates flow in the N aquifer only. The following sections include a brief description of each of these three models.

USGS Black Mesa Model—This model, referred to hereafter as the USGS model, was documented by Brown and Eychaner (1988). The one-layer model simulates flow in the N aquifer only. A head-dependent boundary is implemented to simulate leakage into the N aquifer from the overlying D aquifer. This arrangement of boundary conditions does not permit calculation of the effects of pumping in the N aquifer on any springs or other outflow features in the D aquifer. Select streams are simulated using the MODFLOW River Package (Harbaugh, 2005). Thomas (2002) updated the USGS model with additional simulation time and groundwater pumping for the period 1985–99; however, no recalibration of the model has been carried out. The model has been converted from an earlier version of MODFLOW to run with MODFLOW-2000 (Harbaugh and others, 2000) and MODFLOW-2005 (Harbaugh, 2005).

Western Navajo Hopi N Aquifer Model—This model was constructed by Peter Mock as a subcontractor to Southwest Ground-Water Consultants, who in turn was a subcontractor to HDR Engineering Inc. The model, referred to hereafter as the WNHN model, is documented in volume 3 of HDR Engineering, Inc. (2003). Model data sets were available to run in MODFLOW-96 (Harbaugh and McDonald, 1996). This model uses five layers to simulate groundwater flow in the D and N aquifers and intervening rock units. The areal extent of the WNHN model includes the area of the N aquifer shown in figure 1. The larger areal extent relative to the PWCC and USGS models could be an advantage because it allows for evaluation of effects of pumping in more of the N aquifer. Select streams are simulated using the MODFLOW River Package (Harbaugh, 2005). In converting the WNHN model data sets to run on a currently supported version of MODFLOW, several of the model layer-surface arrays were found to be internally inconsistent. The model cannot be directly converted for use in its present state and should not be considered for use by the NGS-KMC EIS until problems are fixed and data sets are converted for use in a current version of MODFLOW.

Peabody Western Coal Company (PWCC) Model—This model, referred to hereafter as the PWCC model, is an update of an earlier model by Peabody Western Coal Company, Inc. (1999). The model documentation was released in January 2015 (Tetra Tech, 2014). The PWCC model uses seven model layers to simulate groundwater flow in the D and N aquifers and intervening rock units. According to Tetra Tech (2014), improvements in the model over the version documented in Peabody Western Coal Company, Inc. (1999) include

1. Conversion to run with MODFLOW-NWT (Niswonger and others, 2011);
2. Modified time discretization to simulate from 1956 through 2012;
3. Implementation of the Multi-Node Well Package (Konikow and others, 2009);
4. Implementation of the Streamflow-Routing Package, version 2 (Niswonger and Prudic, 2005);
5. Simulation of evapotranspiration along washes;
6. Simulation of additional springs;
7. Implementation of a flow barrier to simulate restriction of flow across a monocline;
8. Calibration of hydraulic conductivity using pilot-point methodology;
9. Modification of storage properties; and
10. Modification of the distribution of groundwater recharge.

General Comments on Evaluated Models

The USGS model has deficiencies that preclude its use by the NGS-KMC EIS. As mentioned previously, this model cannot evaluate effects of pumping on springs and other features connected to the D aquifer. Also, the USGS model used the River Package (Harbaugh, 2005) to simulate flow between the N aquifer and streams such as Laguna Creek and Moenkopi Wash. Unless a stream or river is continuous and removes water from the aquifer domain, use of software packages such as River or Drain will result in the incorrect calculation of capture from groundwater pumping. The correct approach for streams including perennial and ephemeral reaches is simulation with the Streamflow-Routing Package (SFR1, Prudic and others, 2004; or SFR2, Niswonger and Prudic, 2005) or the Stream Package (STR) (Harbaugh, 2005). These packages were not available when the USGS model was constructed.

Of the three models evaluated, the WNHN model has the largest model domain for general use by the NGS-KMC EIS. The inconsistency problems with the layer-surface arrays, however, preclude its use in evaluating effects of pumping. This model also has the same problem as the USGS model in representation of surface-water features with a package other than STR, SFR1, or SFR2.

The PWCC model has an areal domain that is intermediate in size (fig. 1) of the three models evaluated and it has the most detailed vertical discretization of the D and N aquifers. This model has the most up-to-date calibration and it is set up to run on a relatively recent version of MODFLOW using more sophisticated boundary-condition packages than were employed for the USGS and PWCC models.

Comparison of Model-Calculated Steady-State Water Budgets

In spite of problems with the USGS and WNHN models, these models were used to help understand ranges of estimates of steady-state water-budget components for the same or similar areas of the N aquifer. Inflow water-budget items for the N aquifer part of models in the study area include recharge, net leakage from the overlying D aquifer, and specified flow. Outflow items of interest include evapotranspiration, flow to springs, and flow to streams. The WNHN model could not be run, but HDR Engineering Inc. (see volume 3, task 4.2, table 26, 2003) includes steady-state water budgets for the part of the WNHN model that is within the domain of the USGS model. Computation of water budgets for a subarea of a larger model likely will indicate lateral flow crossing the boundary into and out of the subarea. Net lateral flow out of the USGS model domain, therefore, is an additional water-budget item for the USGS subarea within the WNHN model. A comparison of steady-state water-budget components for the three models is shown in figure 2.

The range in magnitude of the three budgets—11,900 to 13,600 acre-ft/yr—indicates general agreement; however, the PWCC budget has the lowest magnitude and the largest water-budget domain in this comparison. The USGS and the WNHN models have nearly the same water budget magnitude for the sub-area encompassed by the USGS model. Some specific differences, however, exist in the individual water-budget components. The PWCC model simulates that more than half of the groundwater discharge is through evapotranspiration, whereas the other two models simulate lesser proportions of discharge to evapotranspiration. Another difference is that

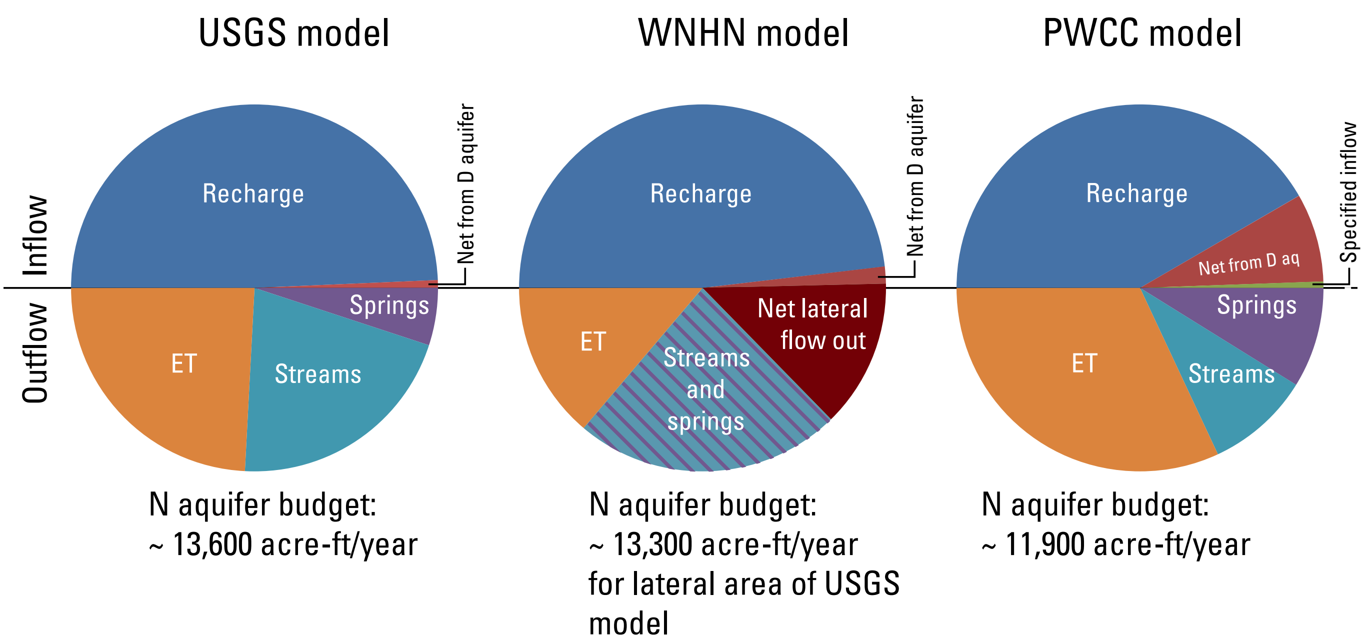


Figure 2. Comparison of N aquifer steady-state water budgets from the Peabody Western Coal Company, U.S. Geological Survey, and Western Navajo Hopi N aquifer models. The water-budget domain includes all of layers 5-7 in the Peabody Western Coal Company Model, all of layer 1 in the US Geological Survey model, and the portion of layer 5 in the Western Navajo Hopi N aquifer model that coincides with the areal extent of the US Geological Survey model.

the PWCC model simulates considerably more leakage from the D aquifer to the N aquifer for the same area as is represented by the other two water budgets. Finally, the WNHN model simulates a significant amount of net lateral flow out of the USGS model domain. Some of the no-flow boundaries of the USGS model were designed to coincide with flow lines that might have been inferred from contour maps of observed water-level data. The fact that there is a significant amount of simulated net flow out of the USGS model domain within the WNHN model indicates that the USGS model boundaries do not coincide with flow lines being calculated by the WNHN model.

Evaluation of the Technical Design and Calibration of Model Most Appropriate for use by the EIS Team

Because of the limited areal extent of the USGS model, the inconsistencies of the layer surface arrays in the WNHN model, and because neither of these models use the STR, SFR1, or SFR2 packages to simulate streams, the PWCC model (Tetra Tech, 2014) is the most appropriate existing groundwater flow model for use by the NGS-KMC EIS team. This evaluation provides comments on the aspects of the design of this model including the MODFLOW version used; model grid dimensions and discretization; time discretization; internal and perimeter boundary conditions, including a separate section on recharge; aquifer storage properties and hydraulic diffusivity; and model calibration.

MODFLOW Version Used

The PWCC model uses MODFLOW-NWT, which is a version of the USGS MODFLOW-2005 code that uses the Newton-Raphson formulation to improve solution of unconfined groundwater-flow problems (Niswonger and others, 2011). Application of MODFLOW-NWT is appropriate in hydrogeological settings such as the combined D and N aquifer system in the area of Black Mesa. Use of the PWCC model using MODFLOW-NWT resulted in numerically stable results for any test runs done as a part of the analyses described in this report. The PWCC model using MODFLOW-NWT likely will perform well for projection runs done by the NGS-KMC EIS team.

Model Grid

The model grid in the PWCC model (Tetra Tech, 2014) is the same as was used in the earlier version of the model (Peabody Western Coal Company, Inc., 1999). The horizontal grid consists of 145 rows and 175 columns of finite-difference cells. Grid dimensions are non-uniform, with the smallest cell sizes of 1,640 ft by 1,640 ft near the PWCC well field, and the largest cell sizes of 24,606 ft by 24,606 ft in the southeastern part of the model. The grid is rotated counter-clockwise 45 degrees about the northwest corner of the grid, which corresponds to row 1, and column 1 of the grid.

The model grid consists of seven layers, each representing a different hydrostratigraphic unit (HSU) in the aquifer system. Model layer 1 represents the shallowest part of the aquifer system and layer 7 represents the deepest part. The seven model layers and corresponding HSUs are as follows:
Layer 1– Dakota Sandstone
Layer 2– Morrison Formation
Layer 3– Cow Springs Sandstone and Entrada Sandstone
Layer 4– Carmel Formation
Layer 5– Navajo Sandstone
Layer 6– Kayenta and Moenave Formations
Layer 7– Wingate Formation
Layers 1–3 make up the D aquifer and layers 5–7 make up the N aquifer. Layer 4 is a confining unit that separates the D and N aquifers. HSUs not simulated as model layers include the Mancos Shale and the Mesa Verde Group above Layer 1, and the Chinle Formation below layer 7. Both the Mancos Shale and Chinle Formation are confining layers that have an effect of restricting movement of water between adjacent aquifers.

In the horizontal and vertical dimensions, the PWCC model grid provides ample resolution to simulate groundwater flow in the aquifer system. A reasonable model probably could be constructed with coarser minimum cell sizes, but the sizes used in the PWCC model allow for more accurate representation of locations such as wells, springs, streams, evapotranspiration areas, and other features such as extents of HSUs. Similarly, fewer model layers could have been used to simulate the aquifer system. For example, the USGS and WNHN models used a single layer to represent the N aquifer. The WNHN model also used one layer to represent the D aquifer, but used three layers to represent the Carmel Formation. Possible negative aspects of the finer vertical discretizations for the D and N aquifers in the PWCC model are increased simulations times and difficulties in reaching a stable numerical solution. The PWCC model run times, however, are manageable and the original model runs and test runs made for this evaluation reached stable numerical solutions. The finer resolution of the Carmel Formation using three model layers in the WNHN model allows for a better approximation of the timing of head and storage changes in the unit and flow through the unit in response to changes such as pumping in the overlying and underlying units. The benefit of the additional vertical resolution of the confining unit, however, diminishes with time since the onset of increased pumping in an adjacent aquifer. For example, timing in release of water from an adjacent confining unit over periods of a few hours or days after the onset of pumping is best approximated using multiple layers to represent the confining unit. After longer periods, however, representation of the confining unit as a single model layer may result in reasonable estimates in release of water from the confining unit. Other than the WHNW model, no tests of effects of confining-unit vertical discretization have been run using models that include the Carmel Formation, but results of simulations of this HSU with a single model layer may be similar to results using three or more model layers for transient simulation times in the range of years to decades.

Time Discretization

Initial conditions for the PWCC model in January 1956 were assumed to be steady-state. Those conditions were obtained by running a transient model without any changes in boundary conditions for a thousand-year period. The calculated heads from that simulation were used as starting heads for the PWCC transient model run, which simulates the time period from January 1956 through December 2012. This period is broken up into 58 stress periods, all of which are 1 year in length except for two half-year stress periods that were used to simulate calendar year 1985, when there was a significant reduction in groundwater pumping in the coal-lease area. Simulation time was further broken down to four 3-month time steps within each 1-year stress period and four 1.5-month time steps within the two half-year stress periods. The time discretization appears to be adequate for the PWCC transient model run documented by Tetra Tech (2014). Simulation with a coarser time resolution may have been possible, but that would not have improved any aspect of the model other than model run times.

Recharge

Recharge from precipitation in the PWCC model was based on the recharge distribution used in the previous model (Peabody Western Coal Company, Inc., 1999), which was calculated using an approach similar to the Maxey-Eakin method. For the PWCC model, three zones were added so that multipliers could be used to reduce recharge, which reduces calculated heads, in some areas and increase recharge, which increases discharge to surface water, in other areas. The resulting distribution of recharge, shown in figure 3, was used in the predevelopment simulation and was held constant throughout the transient simulation. Total recharge within the model domain was about 12,200 acre-ft/yr.

As a part of this evaluation, recharge for the PWCC model active area was calculated using the Basin Characterization Model (BCM; Flint and Flint, 2008). The BCM is a distributed-parameter water-balance model that estimates in-place runoff and in-place recharge for 270-meter grid cells. Parameters in the equations include monthly estimates of precipitation, maximum and minimum air temperature, and potential evapotranspiration. For more details on the BCM, see Flint and Flint (2008). The 1940–2008 average in-place recharge rate calculated by the BCM for the active area of the PWCC model not overlain by the Mancos Shale was about 13,900 acre-ft/yr. That amount of recharge is distributed over the active area of the PWCC model as is shown in figure 4. Yearly BCM total in-place recharge for the PWCC model active area and precipitation at Tuba City for years 1940–2008 are shown in figure 5.

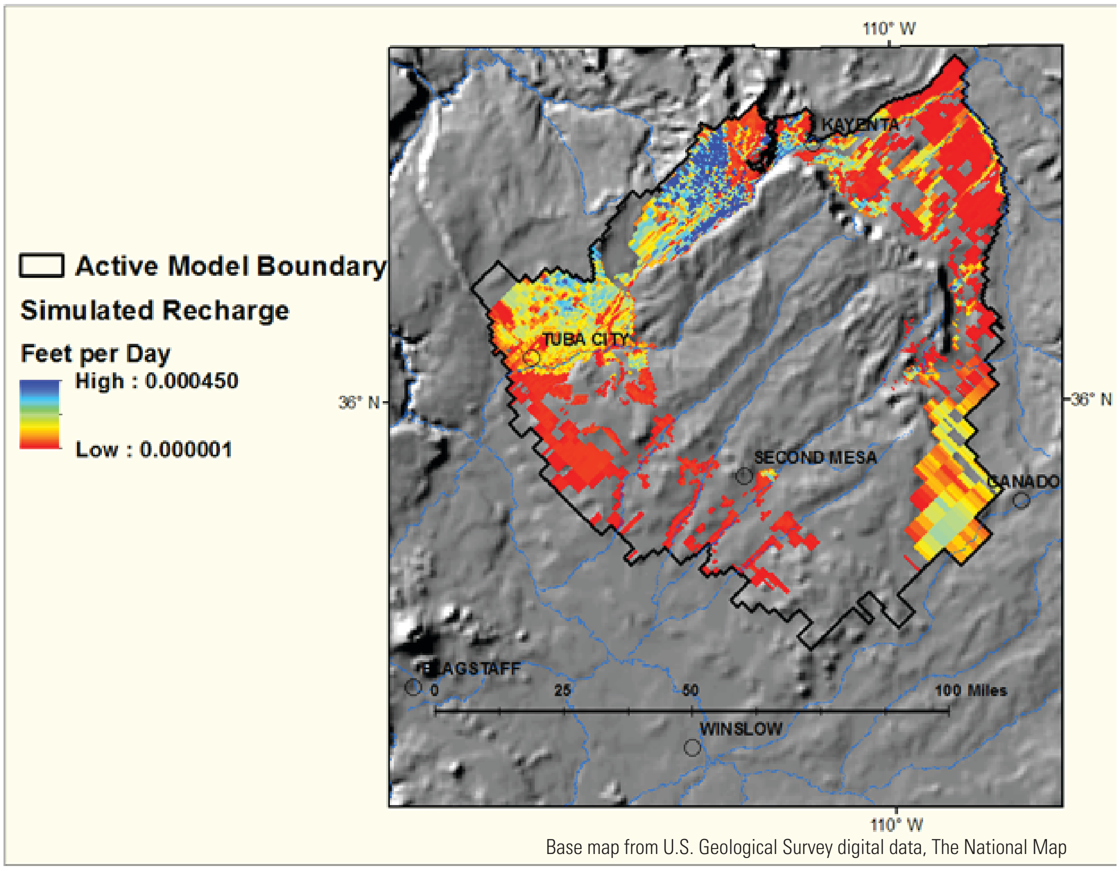


Figure 3. Distribtion of recharge from precipitation simulated in the Peabody Western Coal Company model. Areas in the active model boundary with no color in the range of the color bar have zero simulated recharge from precipitation.

These simulated results show the episodic nature of recharge in the study area.

Prior to publication of the PWCC model, Tetra Tech (2014) reran the model using the BCM-calculated recharge distribution shown in figure 4. Overall results were similar to results from the run with the recharge distribution shown in figure 3, with improvements in model fit of head and flow observations in some areas and degraded fits in other areas. Recalibration of the model with the BCM recharge distribution, however, was beyond the scope of the Tetra Tech (2014) model effort. For a more detailed comparison of results using the original PWCC model recharge and BCM recharge, see section 4.3 “Comparison to BCM Recharge” in Tetra Tech (2014). Recharge is difficult to estimate with certainty for most groundwater systems, and the total long-term average recharge estimates of 12,200 acre-ft/yr and 13,900 acre-ft/yr by Tetra Tech (2014) and BCM, respectively, are fairly close. A different recharge distribution in a model will not affect the timing of calculated responses to pumping unless the change in recharge results in a change in hydraulic diffusivity or configuration of the boundary conditions. In the PWCC model, changing from the original recharge distribution to the BCM recharge distribution likely would result in only minor differences in simulated responses to pumping. Use of the PWCC model by the NGS-KMC EIS team with the original recharge distribution therefore is reasonable. For future models of the D and N aquifers in the Black Mesa area, use of time-varying recharge distributions calculated by BCM or another water-balance model would allow for better separation of climatic and human-caused effects on groundwater levels and flow in springs and streams. Use of time-varying recharge also could help in the calibration of aquifer storage properties.

Other Boundary Conditions

In groundwater models that are used to assess the effects of pumping, significant hydrologic features such as streams, springs, and groundwater evapotranspiration areas should be represented using an appropriate head-dependent boundary. MODFLOW packages commonly used to represent these features include Drain, River, Stream, Streamflow Routing version 1, Streamflow Routing version 2, and Evapotranspiration Packages. Failure to represent a groundwater discharge feature in a model would mean that calculated drawdown and the timing and locations of capture from nearby pumping would be incorrect.

In the PWCC model, streams and springs that contribute directly to streamflow are represented with the Streamflow-Routing Package, version 2 (Niswonger and Prudic, 2005);

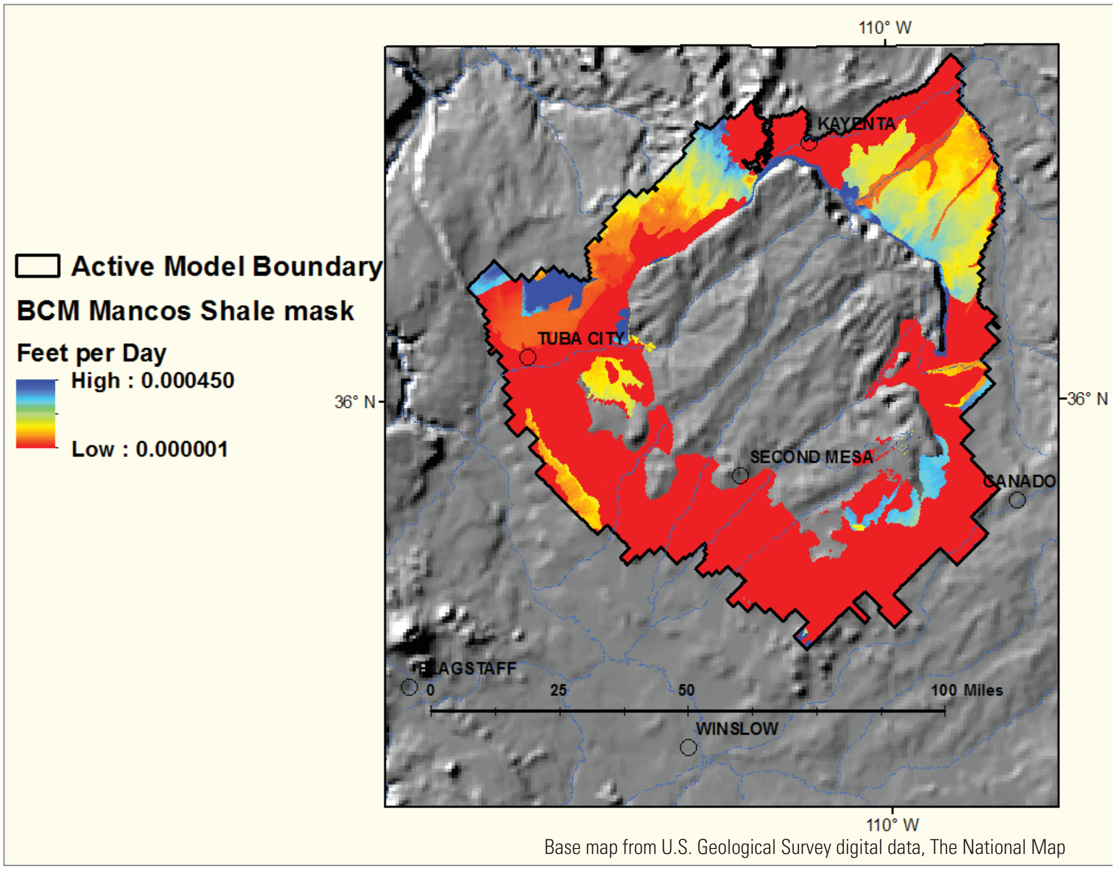


Figure 4. Distribution of 1940-2008 average recharge from precipitation calculated by Basin Characterization Model (BCM). Areas in the active model boundary with no color in the range of the color bar have zero computed recharge from precipitation.

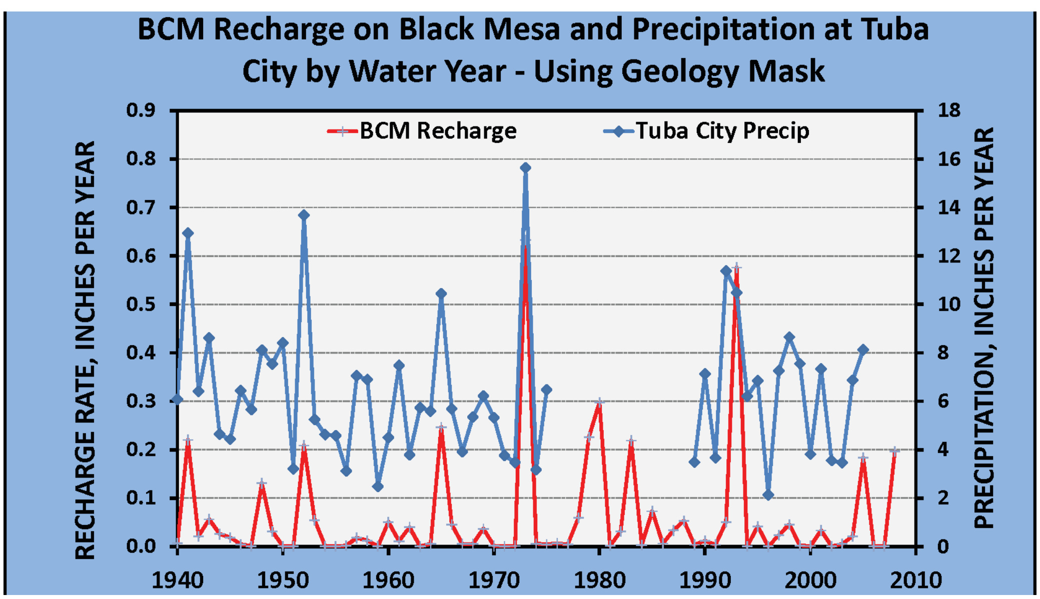


Figure 5. Yearly basin characterization model recharge in the Peabody Western Coal Company active model area and precipitation at Tuba City, 1940-2008.

other springs and seeps were simulated using the Drain Package; and evapotranspiration along washes was simulated using the Evapotranspiration Package. This combination of MODFLOW packages used to represent real hydrologic features leads to improved simulation capabilities in comparison to previous models including the original PWCC (1999) model, the USGS model, and the WNHN model. In particular, use of the Streamflow-Routing and Evapotranspiration Packages will allow for improved simulation of responses to pumping from the N and D aquifers.

In constructing a groundwater model, care must be taken to not include artificial boundaries that can affect the calculation of drawdown or capture from simulated pumping. Ideally, model boundaries should represent real features such as rocks of low permeability that are laterally or vertically adjacent to the aquifer. With many groundwater models, however, artificial boundaries are used to simulate a domain that is smaller than the actual extent of an aquifer. Reilly and Harbaugh (2004) state, “When physical hydrologic features that can be used as boundary conditions are far from the area of interest, artificial boundaries are sometimes used. The use of an artificial boundary should be evaluated carefully to determine whether its use would cause unacceptable errors in the model.” Table 1 shows the types of artificial boundaries commonly used to limit the extent of a model, and the effects that those boundary conditions can have on the calculation of drawdown and storage change, and capture from real physical features such as streams, springs, wetlands, and evapotranspiration areas.

Artificial boundaries in the PWCC model have been identified on figure 1. Lateral perimeter boundary segments are denoted with red dashed line segments labeled A–F. According to Chris Gutman (Tetra Tech, oral commun., September 2015) boundary segments A and C are artificial no-flow boundaries that correspond to suspected groundwater divides or flow lines. Boundary segment B is a mixed no-flow/specified-flow boundary. Three injection wells in model layer 5 along this boundary provide additional inflow to the model to help calibrate calculated head in this part of the model. Boundary segment D is a head-dependent flow boundary in model layer 5 simulated with the Drain Package. This boundary simulates flow to springs and seeps in canyons to the northwest of this segment, outside of the model domain. Boundary segment E includes some head-dependent flow boundary cells in layers 5 and 6, simulated with the General-Head Boundary Package. The intent of this boundary is to simulate groundwater underflow across the edge of the model domain in the area of the confluence of Laguna Creek and Chinle Wash. Segment F is a mixed no-flow and head-dependent flow boundary. The lateral extent of the model in this area is defined by the edge of active cells in model layers 6 and 7. Along this segment, Chinle Wash is represented with the Streamflow-Routing Package, version 2 at select cells in layers 6 and 7. Groundwater flow and changes in groundwater flow under Chinle Wash is not allowed by the configuration of this boundary. Boundary segments not denoted with a red dashed line on figure 1 are thought to correspond with the edge of saturated parts of the N aquifer. These segments are represented as no-flow boundaries in the model. The green hachured area on figure 1 corresponds to an artificial boundary designed to simulate flow through the Mancos Shale to the D aquifer, using the River Package. For simulation of transient changes in flow, this is an artificial boundary that does not account for storage changes in the Mancos Shale or ultimate effects of changes in flow in HSUs above the Mancos shale.

Table 1. Types of artificial boundaries commonly used to limit the extents of the simulated domains in models of groundwater flow.

Type of artificial boundary	MODFLOW package(s) typically used to simulate boundary	Common justifications for using artificial boundary type	Possible negative effect(s) of artificial boundary on calculated drawdown and storage change for simulation of groundwater withdrawal	Possible negative effect(s) of artificial boundary on calculated capture and streamflow depletion for simulation of groundwater withdrawal
No-flow	Basic	A groundwater divide or flow line is an effective no-flow boundary	Overestimation within the simulated model domain	Overestimation within the simulated model domain
Specified-flow	Well	The rate of groundwater flow between a part of an aquifer and an adjacent part of an aquifer is assumed to be known	Overestimation within the simulated model domain	Overestimation within the simulated model domain
Constant-head	Constant-Head, Basic	Head along a boundary segment is assumed to be known from contours of measured groundwater levels	Underestimation within the simulated model domain	Underestimation within the simulated model domain
Head-dependent flow	General-Head, Drain, River	Flow to or from adjacent area can be approximated with function Q=f(h), where Q is flow across segment, and h is computed head at the boundary segment	Underestimation or overestimation within the simulated model domain, depending on the hydraulic conductance of the boundary	Underestimation or overestimation within the simulated model domain, depending on the hydraulic conductance of the boundary

The artificial boundaries in the PWCC model are of types that are commonly used to limit the extent of a model to a manageable size. The placement and types of the artificial boundaries do not seem to limit the usefulness of the model for evaluating effects of pumping in the coal-lease area. If this model is used for assessments of effects of pumping throughout the model domain, effects of the artificial boundaries should be assessed. Ideally, there should be little or no drawdown around artificial no-flow or specified-flow boundaries, and there should be no or small changes in flow to or from artificial head-dependent boundaries.

Aquifer Storage Properties and Hydraulic Diffusivity

Physical processes that result in increase and decrease in storage of water in the D and N aquifers and confining units in the study area include filling and draining pore spaces at the water table, expansion and compression of the sediment skeleton, and expansion and compression of water. In the MODFLOW-NWT Upstream Weighting Package used in the PWCC model, specific yield is the aquifer storage property relating to draining and filling of pore spaces at the water table and specific storage is the property relating to compression and expansion of the sediment skeleton and water.

Specific yield in the PWCC model was set to 0.1 everywhere except for a zone in layer 5 where a value of 0.13 was used. Both the USGS and WNHN models used a value of 0.1 for specific yield for all aquifers and confining units simulated. Values of specific yield in the PWCC model are largely consistent with previously modeled values and are in a reasonable range for aquifers in the study area.

A specific storage value of 3.05×10^{-7} ft^{-1} was specified for all active cells in the PWCC model. MODFLOW-NWT uses this storage property for any cells in which head is above the top of the cell—otherwise, specific yield is applied. The WNHN model used a value of 1×10^{-7} ft^{-1} throughout that model domain. The specific storage in the USGS model cannot be readily obtained because the storage property specified in that model is the product of specific storage and aquifer thickness. Specific storage can be broken up into skeletal and water components as follows:

$$S_s = S_{sk} + S_{sw} ,$$

where S_s is total specific storage, S_{sk} is skeletal specific storage, and S_{sw} is water specific storage. S_{sw} can be calculated as follows:

$$S_{sw} = \theta\gamma_w / E_w ,$$

where θ is porosity; γ_w is the unit weight of water, 62.4 pounds per cubic foot (lb/ft^3);and E_w is the bulk modulus of elasticity of water, 3.5×10^7 pounds per square foot (lb/ft^2). Using the above equation with an assumed porosity of 0.2 results in an S_{sw} of 2.77×10^{-7} ft^{-1}, and a porosity of 0.25 results in an S_{sw} of 3.47×10^{-7} ft^{-1}. Assuming that 0.2–0.25 is a reasonable range for porosity of unweathered rocks in the model domain, the total specific storage value in the PWCC model, 3.05×10^{-7} ft^{-1}, accounts for the process of expansion and compression of water, but not of the sediment skeleton. A slightly larger value that accounts for some compressibility of the sediment skeleton in aquifers and confining units as well as of water may have been better. An effect of a storage property that is too low is that drawdown from pumping will propagate faster than it would with a correct higher storage property. If, on the other hand, porosity is lower than 0.2, the specific storage value used in the PWCC model will account for compressibility of the sediment skeleton as well as of water in the pore spaces.

Hydraulic diffusivity is the key parameter that controls the rate of propagation of drawdown and other changes in head from system stresses such as removal or addition of groundwater. In a system dominated by horizontal groundwater movement, hydraulic diffusivity is defined as

$$D = K_h b / S_s b ,$$

where D is hydraulic diffusivity, K_h is horizontal hydraulic conductivity, and b is aquifer thickness. The product of K_h and b, transmissivity, is commonly estimated by aquifer tests. The diffusivity equation applies where head in the aquifer is above the top of the aquifer. In areas where unconfined conditions exist, $S_s b$ in the denominator should be replaced with S_y (specific yield). Where vertical flow exists, the ratio K_v / S_s, where K_v is vertical hydraulic conductivity, also may be an important parameter that affects the rate of propagation of changes in head in the vertical direction. For this study, an evaluation of simulated aquifer diffusivity in the PWCC and USGS models was carried out for cells within a 20,000-ft radius of well NAV8 in the coal lease area (table 2 and fig. 1). In table 2, values are given for layers 1–7 of the PWCC model, and values of certain properties are summed for layers 5, 6, and 7, which make up the N aquifer in that model. The row in table 2 that sums PWCC-model properties for layers 5–7 can be compared to the last row in the table, which corresponds to the N aquifer in the USGS model. The Elastic storage coefficient for the PWCC model is calculated as the product of specific storage and aquifer thickness. In the USGS model, the elastic storage coefficient was read directly into the Block-Centered Flow Package. The 20,000-ft radius encompassed 460–466 active cells for each of layers 1–7 of the PWCC model and 58 active cells for layer 1 of the USGS model. The two models indicate some differences in transmissivity and storage coefficient in this region, but the average diffusivity values of about 1.58×10^6 ft^2/day and 1.46×10^6 ft^2/day for layers corresponding to the N aquifer in the PWCC and USGS models, respectively, are fairly close.

Model Calibration

The PWCC model was calibrated using both manual and automatic methods. For details on the calibration procedures

Table 2. Arithmetic averages of select aquifer properties within a 20,000-foot radius of well NAV 8.

[ft, feet]

Model layer	Aquifer thickness (ft)	Horizontal hydraulic conductivity (ft/day)	Transmissivity (ft^2/day)	Specific storage (ft^{-1})	Specific yield, dimensionless	Elastic storage coefficient, dimensionless	Diffusivity (ft^2/day)
				PWCC			
1	153.18	0.152974	23.43	3.05×10^{-7}	0.1	4.67×10^{-5}	501,554
2	509.91	0.001773	0.9	3.05×10^{-7}	0.1	1.56×10^{-4}	5813
3	428.32	0.027836	11.92	3.05×10^{-7}	0.1	1.31×10^{-4}	91,266
4	134.78	0.01303	1.76	3.05×10^{-7}	0.1	4.11×10^{-5}	42,721
5	791.58	0.431983	341.95	3.05×10^{-7}	0.1	2.41×10^{-4}	1,416,338
6	223.1	0.0003	0.07	3.05×10^{-7}	0.1	6.80×10^{-5}	984
7	290.73	0.05	14.54	3.05×10^{-7}	0.1	8.87×10^{-5}	163,934
5+6+7	1,305.41		356.56[1]			3.98×10^{-4}	1,581,256
				USGS			
1	981.9	0.588453	576.38		0.1	3.94×10^{-4}	1,462,893

[1]Transmissivity shown here is the sum of average transmissivity values for layers 5, 6, and 7.

and statistical results of matching targets of head and flow quantities, see section 3 of Tetra Tech (2014). Sensitivity analyses are detailed in section 4 of that report. Automatic calibration was carried out using programs PPEST (Doherty, 1998) and PEST (Doherty, 2013). For this procedure hydraulic property zones throughout the model domain were used. For the Navajo Sandstone, hydraulic conductivity was estimated with 19 pilot points at locations with prior information and an additional 20 or 21 pilot points at other locations. Quantitative calibration targets included hydraulic head in the D and N aquifers, drawdown in the N aquifer, particularly in and around the coal lease area, flow in streams and springs, and evapotranspiration rates inferred from a greenness index obtained from a Land Remote-Sensing Satellite (LANDSAT) image taken on June 13, 2005. Other information used in calibration included observations of flow patterns, lack of wet channels in areas devoid of phreatophytes, and locations of interaction of groundwater and surface water in Moenkopi Wash, Laguna Creek, Dinnebito Wash, Polacca Wash, and Begashibito Wash.

Given the complexity of the N and D aquifer system in the study area and the amount and types of data available, the calibration of the PWCC model described in Tetra Tech (2014) seems to be reasonable. Some general comments on the calibration are as follows:

1. As Tetra Tech (2014) points out, other combinations of parameters, zone geometries, and HSU configurations could have been evaluated. The model as configured is not unique. That, however, could be said about any model constructed with currently available data in the study area. Uniqueness of future models can be improved by continued data collection that helps define HSU geometry, aquifer and confining unit properties, and flow rates into, out of, and within the model domain.
2. As shown in figure 3.1-1 in Tetra Tech (2014), the calibrated Navajo Sandstone horizontal hydraulic conductivity distribution shows high and low values centered on some pilot points. The variation across the model domain, however, is smooth, with most values of the parameter within the relatively narrow range of 0.05–10 ft/day.
3. The average calibrated horizontal hydraulic conductivity in layer 5 within a radius of 20,000 ft of well NAV8 is about 0.43 ft/day (table 2). For comparison, the average horizontal hydraulic conductivity in this area in the USGS model is about 0.58 ft/day.
4. Observed streamflow in most of the major washes is simulated reasonably well. Of four major springs with observed discharge, two do not have simulated outflow in the calibrated model. In groundwater models, simulated water-table altitudes and hydraulic heads often are too high in some areas and too low in other areas. Where simulated heads are too low, simulated springs may not flow enough or may not flow at all. As noted in the section “Internal and Perimeter Boundary Conditions,” springs need to be represented to properly simulate propagation of drawdown and changes in groundwater outflow from groundwater pumping. Any future work on the model should focus on getting all known simulated springs to flow in reasonable amounts.

According to Tetra Tech (2014) the recharge multiplier is the most sensitive parameter in the PWCC model. Other important parameters include the evapotranspiration multiplier, various horizontal and vertical hydraulic conductivity pilot point and zone values, and specific storage of the Navajo Sandstone. Future data collection that improves knowledge of aquifer properties and flow rates will allow the model to be improved. It would be possible to use the PWCC model to help guide data collection that would be the most efficient in improving the model.

Evaluation of Appropriate Post-Pumping Period for Analyses of Long-Term Aquifer Effects

The USGS and PWCC models were used for this evaluation. Two hypothetical analyses were carried out to help understand long-term effects of groundwater pumping in the PWCC coal-lease area. The extended-pumping analysis involved simulating effects of pumping for a period of 1,000 years, and the limited-pumping analysis involved pumping for a period of 80 years. For both analyses, all PWCC wells simulated in the PWCC model (Tetra Tech, 2014) were pumped at equal rates totaling 10,000 ft^3/day. The effects evaluated are changes in groundwater outflow, or “capture.” Results and insights from these analyses are included in the following sections.

Jim Burrell (AECOM, written commun., September 12, 2014), stated that the interest is in a target duration that is defined by the maximum impact of pumping in the coal-lease area, rather than a period of time that includes further impacts after project pumping ceases. Project impact is presumed to include drawdown of water levels and capture of water from features including streams, springs, and evapotranspiration areas. In general, capture can include pumping-induced increased inflow to an aquifer as well as reduced outflow from an aquifer. In most aquifers, including the ones in the study area, there is little opportunity for groundwater pumping to increase inflow to an aquifer; most of the capture, therefore, is in the form of decreased outflow from the aquifer. The first type of capture that can be evaluated is referred to here as “global capture.” For any given time, global capture is the rate at which groundwater pumping is supplied from reduced outflow and increased inflow from all simulated features such as springs, streams, and evapotranspiration areas. “Components of global capture” refer to capture from all of a particular type of boundary in a model, such as all springs, all streams, and all evapotranspiration areas. “Local capture” is the rate at which groundwater pumping is supplied from a particular feature or group of features of interest. It is important to realize that the timing of capture is strongly influenced by the distance from the pumping location to a feature from which capture can occur. The timing of local capture from any individual feature may be faster or slower than the timing of global capture, depending on the location of the feature relative to the location of groundwater pumping.

Extended-Pumping Analysis

The objective of this analysis is to see which groundwater outflow features will eventually be affected by pumping in the PWCC coal-lease area and to get a general sense of timing of those pumping effects. The timing of capture from a pumping well is a function of the aquifer geometry, hydraulic conductivity, storage properties, and geometry of features from which reductions in groundwater outflow can occur, including distances of those features from the pumping well. If an aquifer system responds linearly to groundwater pumping, the timing of capture is not a function of the well pumping rate and capture can be expressed as a fraction of the pumping rate (Barlow and Leake, 2012).

Results from this analysis in terms of global capture, expressed as a fraction of pumping rate, and major components of global capture for the PWCC and USGS models are shown in figures 6 and 7, respectively. A direct comparison of global capture for the two models is shown in figure 8. Both models indicate that the process of changing from groundwater storage to capture as the source of pumped water is a long process. After pumping for 1,000 years, the PWCC model indicates that slightly more than 50 percent of the pumping rate will come from capture, and the USGS model indicates that more than 60 percent of the pumping rate will come from capture (fig. 8). Although faster capture is indicated by the USGS model, both indicate that large rates of capture do not occur in short time periods such as one or two decades. In addition to different rates of capture, the relative rates of capture coming from different sources are dissimilar for the two models. For the PWCC model, most of the capture comes from reduced evapotranspiration, with a minor amount coming from reduced discharge to streams (fig. 6). With the USGS model, capture from streams is slightly more than capture from evapotranspiration (fig. 7). A reason for the difference is that streams in the PWCC model are simulated with the Streamflow-Routing Package and streams in the USGS model are simulated with the River and Drain Packages. If streams consist of isolated perennial reaches, then no capture of streamflow in these reaches can occur, even though streamflow depletion can occur. Simulating these configurations of streams with the River or Drain Package will result in unrealistically high calculated capture. If any streams are not continuous and through-flowing to the edges of the aquifer, the simulation approach taken by the PWCC model is correct. Neither model calculates an appreciable amount of capture from springs that are represented with the MODFLOW Drain Package.

Limited-Pumping Analysis

This analysis also was run with the PWCC and USGS models. A comparison of global capture calculated by the two models is shown in figure 9. Those results show the timing of the maximum effect in terms of global capture. Given

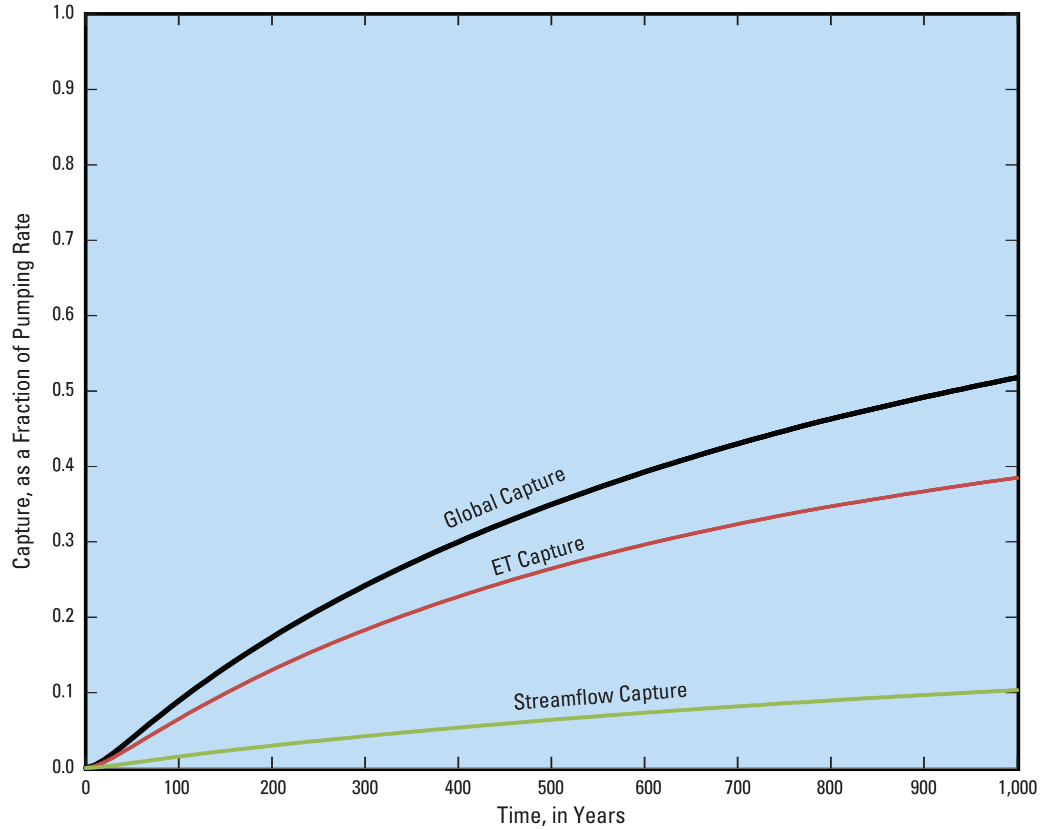


Figure 6. Capture results for the Extended-Pumping Analysis using the Peabody Western Coal Company model. Evapotranspiration (ET).

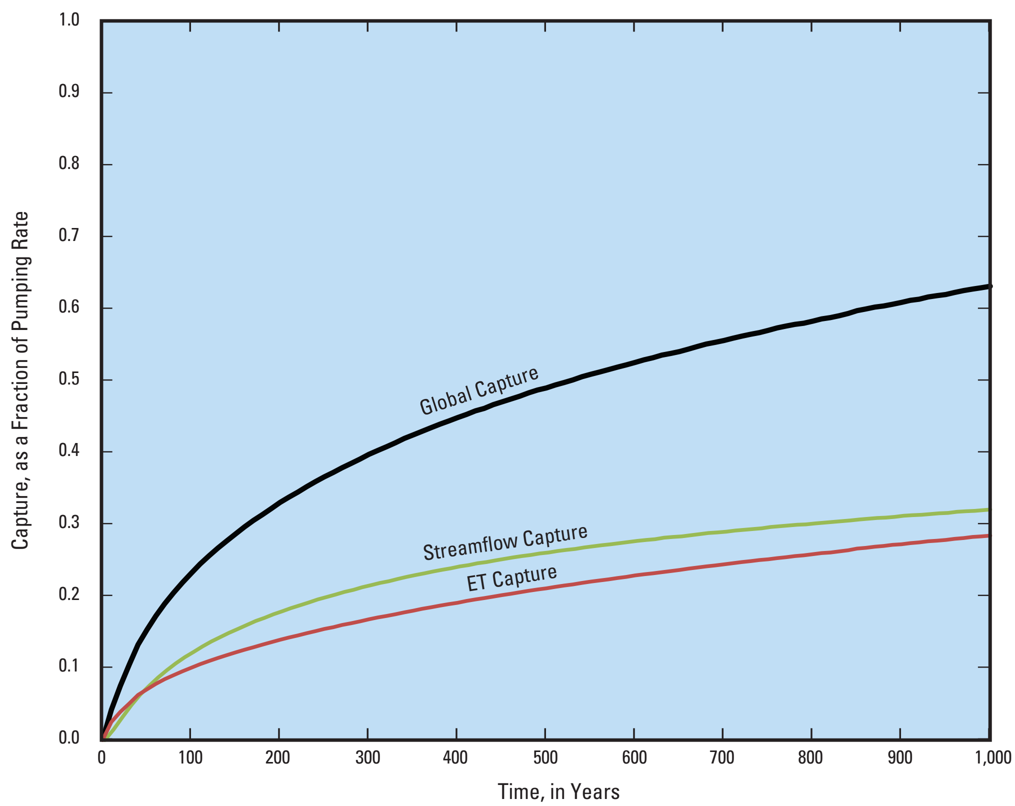


Figure 7. Capture results for the Extended-Pumping Analysis using the U.S. Geological Survey model. Evapotranspiration (ET).

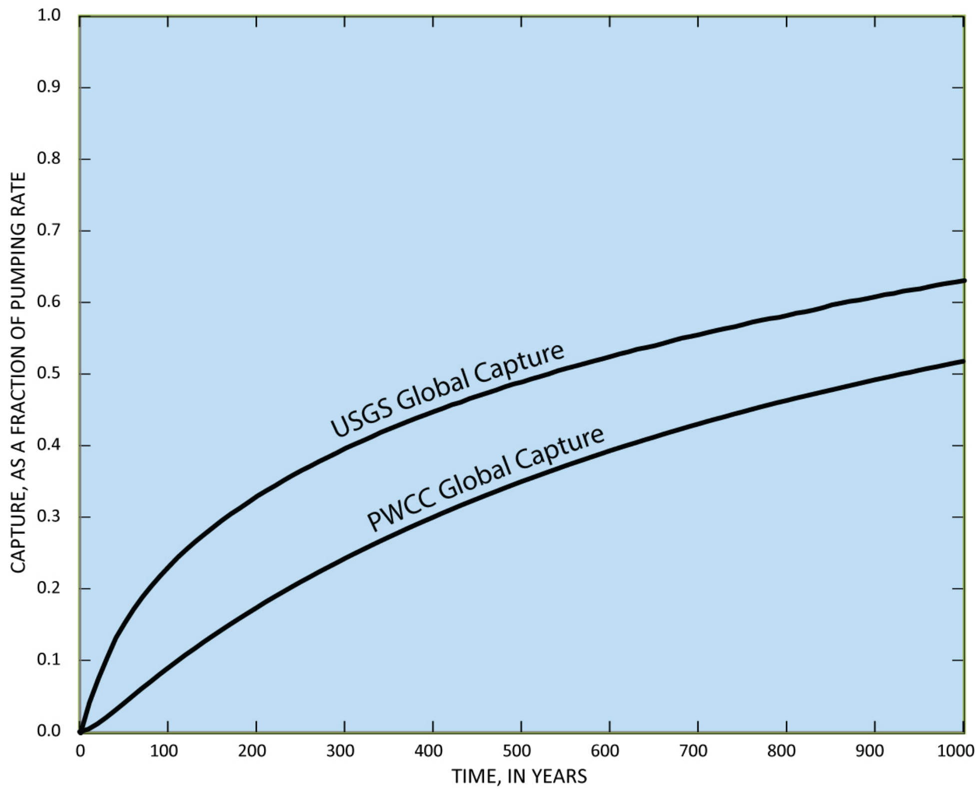


Figure 8. Comparison of global capture computed by the Peabody Western Coal Company and U.S. Geological Survey models for the Extended-Pumping Analysis.

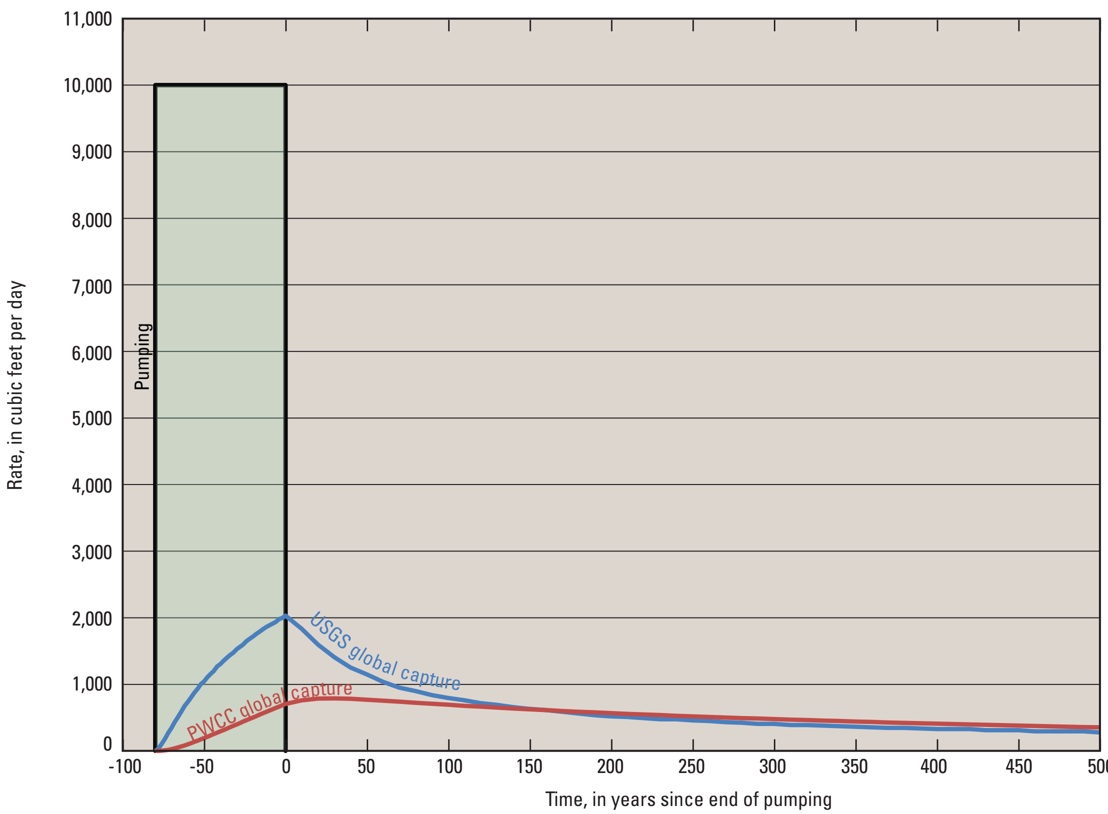


Figure 9. Comparison of global capture computed by the Peabody Western Coal Company and U.S. Geological Survey models for the limited-pumping analysis. In this scenario, all Peabody Western Coal Company mine wells were pumped at a total rate of 10,000 cubic feet per day and then shut off.

enough recovery time, the total volume of global capture will equal the total volume of groundwater pumped. For this analysis scenario, that volume was 292,200,000 ft^3 (about 6,700 acre-ft). For the PWCC model run of this scenario, the total volume captured through time was calculated (fig. 10). After 1,000 years since pumping stopped, slightly half of the volume pumped was accounted for as reduced outflow volume. This means that reduced outflow of almost half of the pumped volume will occur after 1,000 years beyond the cessation of pumping. To counterbalance the long time of residual effects of pumping (reduction of groundwater outflow), the calculated effects for any given time is a small fraction of the quantity of groundwater pumped (fig. 9). As was mentioned previously, the timing of local capture for any given stream, spring, or ET area can be different than the timing of global capture. For example, the maximum capture from a stream that is far from the pumping wells may occur at a much longer time than the time to maximum global capture. There is, however, an inverse relation between the magnitude of maximum capture and distance from the pumping wells. Features closest to the pumping wells are most likely to have significant amounts of capture. Evaluation based on timing of global capture is reasonable because effects on all streams, springs, and ET areas are integrated into a single value. In addition to that measure, analyses of effects of pumping also should look at pumping-induced changes in streamflow at key locations in the simulated stream network.

In the USGS model, maximum global capture occurs when pumping ends. This fast time to maximum capture likely is a result of the unrealistic boundary conditions used for streams. In the PWCC model, maximum global capture occurs about 30 years after pumping ends (fig. 9). If the intent of NGS-KMC EIS model runs is to determine maximum global capture from PWCC mine pumping, a post-pumping (recovery) analysis period of 50–100 years likely would be sufficient. Community pumping occurs at various locations within the model domain, and unlike mine pumping, community pumping is not likely to cease in the future. Evaluations of effects of community pumping on groundwater outflow will involve making model runs with projected pumping rates at known pumping locations and subtracting calculated outflow quantities from corresponding outflow quantities in a model run with community pumping set to zero.

Evaluation of Water Quality

Several USGS scientific reports have summarized water-quality monitoring in the Black Mesa study area for about the

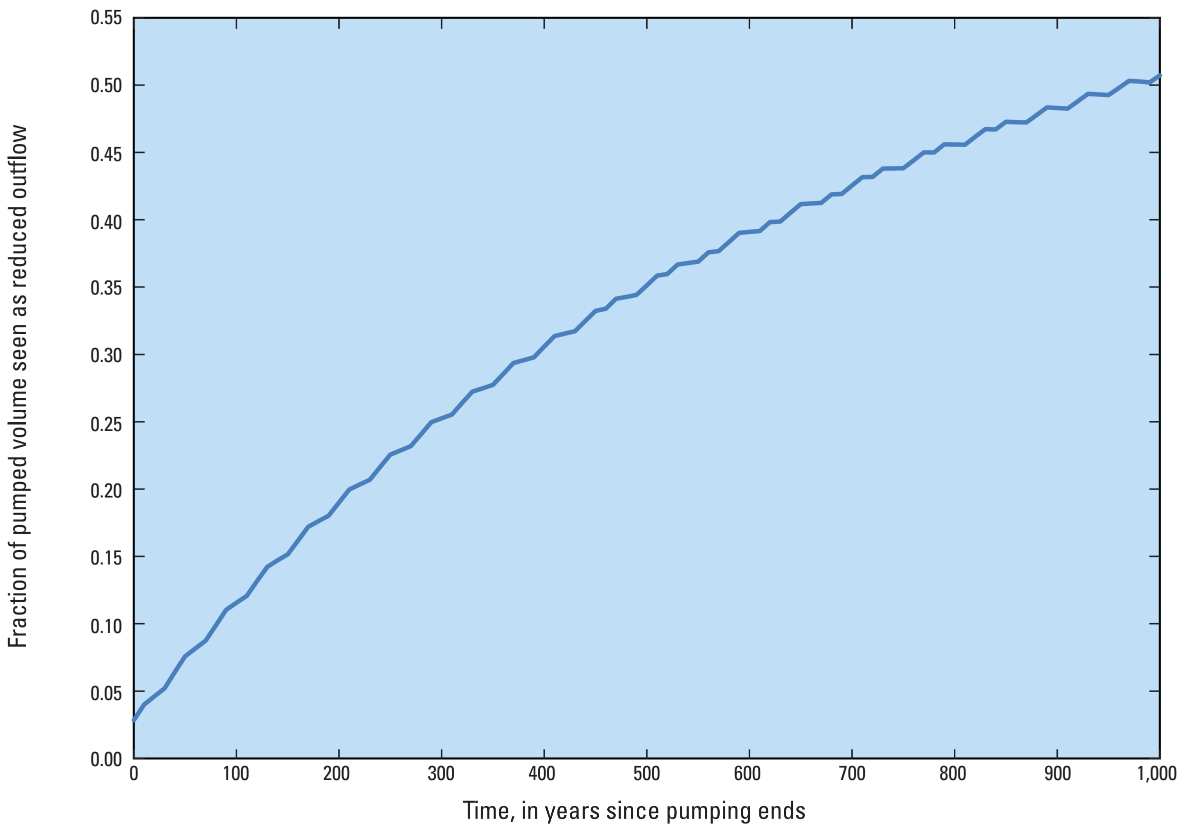


Figure 10. Fraction of the ultimate global caoture volume computed by the Peabody Western Coal Company model for the limited-pumping analysis.

past 40 years (appendix). Annual USGS reports as part of the USGS Black Mesa N Aquifer Monitoring Project document water-quality sampling on an annual basis. Specific conductance, dissolved solids, chloride, and sulfate are monitored on an annual basis because increased concentrations of these constituents in the N aquifer could indicate induced leakage from the overlying D aquifer caused by pumping in the N aquifer. The area of highest leakage occurs in the southern part of Black Mesa, where the N aquifer is thin, the confining layer (Carmel Formation) is less than 120 ft (37 m) thick, and the lithology of the Carmel Formation is more of a sandy-siltstone than a clayey-siltstone (fig. 11). Induced leakage from groundwater development during the last several decades could take centuries to detect geochemically because of the increased vertical difference between the potentiometric surface of the D and N aquifers, and possibly because of increases in the hydraulic gradient in the N aquifer that would increase flow rates, causing dilution (Truini and Longsworth, 2003). On average, the concentrations of dissolved solids in water from the D aquifer is about 7 times greater than that of water from the N aquifer; concentration of chloride ions is about 11 times greater, and concentration of sulfate ions is about 30 times greater (Eychaner, 1983). Long-term data for specific conductance, dissolved solids, chloride, and sulfate for the wells and springs sampled each year for the USGS Black Mesa monitoring project are presented in the annual reports. Additional USGS studies and accompanying reports have also documented water-quality conditions in the D and N aquifers. All water-quality information from USGS projects are stored in the USGS Water-Quality System (QWDATA) database and are available through the USGS National Water Information System website (available at http://waterdata.usgs.gov/nwis).

For this investigation, water-quality information that pertains to the PWCC Tetra Tech and HDR WNHN groundwater model boundaries was retrieved from the USGS QWDATA database and from USGS reports so that the data could be analyzed for trends. Increasing trends in specific conductance, dissolved solids, chloride, and sulfate in water samples from wells or springs in the N aquifer could indicate induced leakage from the overlying D aquifer due to pumping in the N aquifer. A site was analyzed for water-quality trends if 5 years of specific conductance, dissolved solids, chloride, and sulfate data were available for that site. Data for these sites were retrieved from the USGS GWSI and QWDATA databases and compiled in an Excel spreadsheet. Water-quality data were examined for completeness when compared to additional USGS reports to ensure that all available water-quality data are presented in the reporting of this task.

Water-quality data for total dissolved solids, chloride, and sulfate were plotted over time to look for potential trends and twenty-five well sites and four spring sites met the criteria that could indicate induced leakage from the D aquifer to the N aquifer. Statistical analyses used to determine if trends are present in the data included simple linear regression and Kendall's tau. If any trends were found within wells completed in the D and N aquifers, then further investigation using existing data occurred to determine the potential for vertical flow between aquifers, well installation, screening intervals and grouting, and changes in aquifer flow patterns.

Twenty-five well sites met the criteria of a minimum of 5 years of total dissolved solids, chloride, and sulfate data (table 3). Simple linear regression and Kendall's tau statistical analyses for these 25 wells revealed appreciable trends for increased total dissolved solids, chloride, and sulfate in well Shonto PM2, and increased total dissolved solids and chloride in well Keams Canyon PM2. Shonto PM2 is located in the unconfined part of the N aquifer (fig. 12) and, therefore, increasing trends would not indicate induced leakage from the overlying D aquifer. Keams Canyon PM2 is located in the southeastern part of the study area in the confined portion of the N aquifer. The confining layer, the Carmel Formation, in the area of Keams Canyon is between 80 and 100 ft (24 to 30 m) thick, and composed of a more sandy-siltstone rather than the clayey-siltstone observed in the northern part of the study area, where leakage has not been detected (fig. 11; Truini and Macy, 2005). Areas where the Carmel Formation is 120 ft (37 m) thick or less coincide with areas where isotopic ratios of $^{87}Sr/^{86}Sr$ and major-ion data for groundwater indicate that D aquifer water has mixed with N aquifer water as a result of leakage (Truini and Longsworth, 2003). Both the lithologic difference in, and the thickness of, the Carmel Formation near Keams Canyon indicate that leakage could be possible without effects from pumping.

Four spring sites met the criteria of a minimum of 5 years of total dissolved solids, chloride, and sulfate data (table 3). Burro Spring is the only one of the four springs that is found in the confined part of the N aquifer where the D aquifer is overlying, and therefore the only spring where effects from induced leakage of the overlying D aquifer from pumping could be expected. There are no appreciable trends found for sulfate, chloride, or specific conductance at Burro Spring based on simple linear regression and Kendall's tau (fig. 12).

Summary and Conclusions

The Lower Colorado Region of the Bureau of Reclamation is preparing an environmental impact statement for the Navajo Generating Station-Kayenta Mine Complex Project. The EIS includes evaluation of various groundwater-related alternatives that may have effects on the N aquifer, which is the principal water resource in the Black Mesa Basin. Groundwater from the N aquifer is used by the Navajo Nation and Hopi Tribal communities, as well as the Peabody Western Coal Company (PWCC). The USGS was asked by the Bureau of Reclamation to provide technical assistance to the NGS-KMC EIS team in several areas including spring inventory, evaluation of groundwater models, and evaluation of water-quality information. Some key conclusions from this study are outlined in the following paragraphs.

Three groundwater models evaluated for possible use by the NGS-KMC EIS team include the USGS model (Brown and

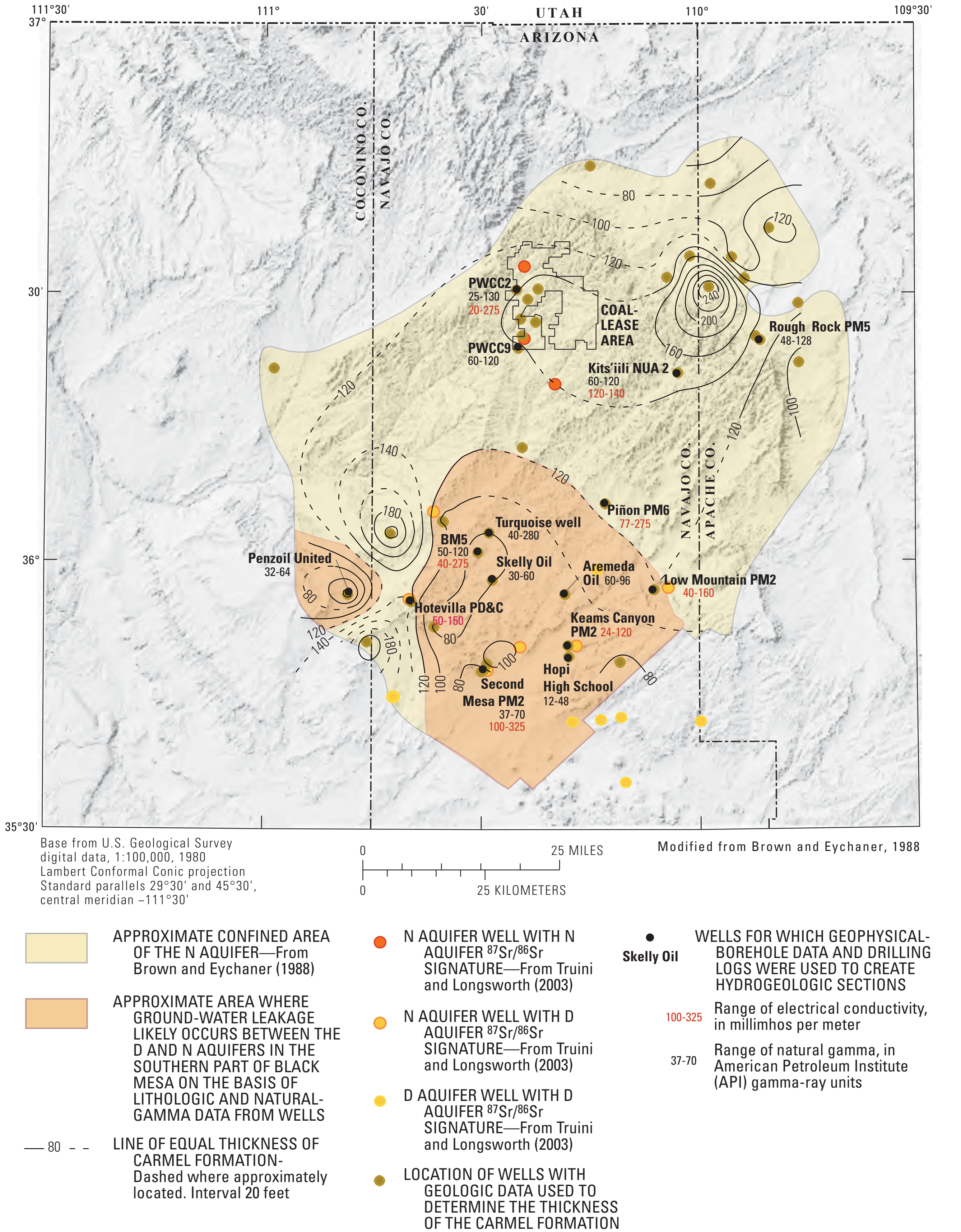


Figure 11. Thickness of the Carmel Formation, ranges of natural gamma and electrical conductivity from borehole-geophysical logs, and relative $^{87}Sr/^{86}Sr$ signatures, Black Mesa, Arizona (modified from Truini and Macy, 2005).

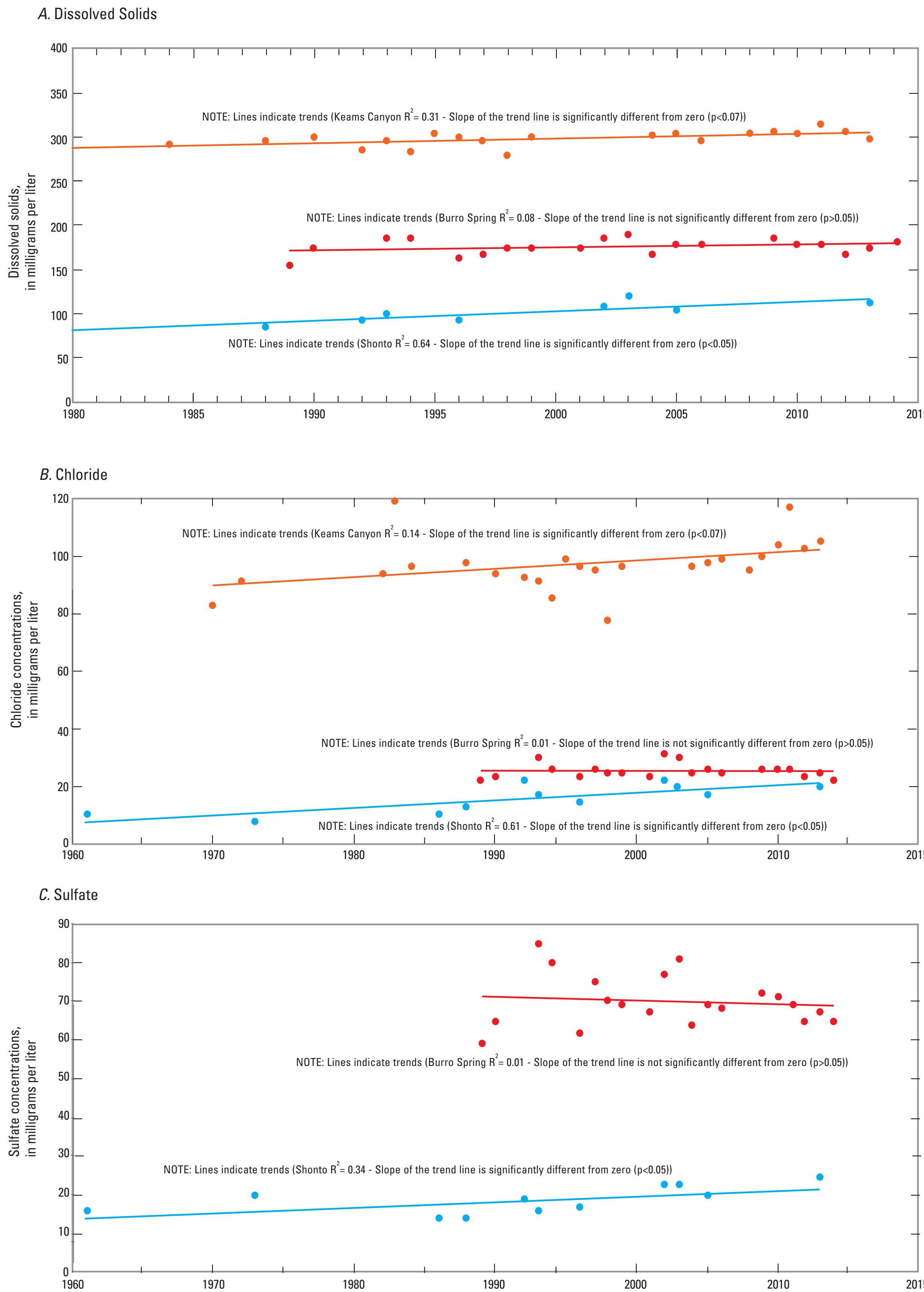


Figure 12. Concentrations of dissolved solids, chloride, and sulfate for water samples from Burro Spring, 1982–2013 *A*, Dissolved solids; B, Chloride; and C, Sulfate. Trend lines were generated by using the method of least squares.

Table 3. Site name and U.S. Geological Survey site ID for wells and springs with a minimum of 5 years of total dissolved solids, chloride, and sulfate water-chemistry data.

Site name	USGS site ID
Wells	
Second Mesa Day School	354749110300101
Keams Canyon PM2	355023110182701
Kykotsmovi PM1	355236110364501
Kykotsmovi PM2	355215110375001
Hotevilla	355518110400301
Low Mountain PM2	355638110064001
Rocky Ridge	360418110352701
Rocky Ridge PM3	360422110353501
Pinon PM6	360614110130801
Forest Lake NTUA1	361737110180301
Red Lake PM1	361933110565001
Kitsillie NTUA2	362043110030501
Chilchinbito PM3	363137110044702
Shonto PM2	363558110392501
Kayenta PM2	364344110151201
Dennehotso PM2	365045109504001
Glen Canyon National Recreation Area	365723111302801
PWCC 2	363005110250901
PWCC 3	362625110223701
PWCC 4	362647110243501
PWCC 5	362901110234101
PWCC 6	363007110221201
PWCC 7	362456110242301
PWCC 8	363130110254501
PWCC 9	362333110250001
Springs	
Moenkopi School Spring	360632111131101
Pasture Canyon Spring	361021111115901
Burro Spring	354156110413701
Unnamed Spring near Dennehotso	364656109425400

Eychaner, 1988), the WNHN model (HDR Engineering Inc., 2003), and the PWCC model (Tetra Tech, 2014). The USGS model was eliminated from consideration for use by the EIS team because it does not simulate groundwater flow in the D aquifer. The WNHN model cannot be used at present because of some problems with layer-surface arrays. The PWCC (Tetra Tech, 2014) model is a recently calibrated model that can simulate the effects of past groundwater development in the D and N aquifers in the Black Mesa area. In the horizontal and vertical dimensions, the PWCC model grid provides ample resolution to simulate groundwater flow in the aquifer system. This model has some artificial boundaries that limit its areal extent within the area of the N aquifer. Because of the limited areal extent of the USGS model, the inconsistencies of the layer surface arrays in the WNHN model, and because neither of these models uses the STR, SFR1, or SFR2 packages to simulate streams, the PWCC model is the most appropriate existing groundwater flow model for use by the NGS-KMC EIS team. The combination of MODFLOW packages used in the PWCC model to represent real hydrologic features leads to improved simulation capabilities in comparison to previous models including the original PWCC (1999) model, the USGS model, and the WNHN model. In particular, use of the Streamflow-Routing and Evapotranspiration Packages will allow for improved simulation of responses to pumping from the N and D aquifers. The placement and types of the artificial boundaries do not seem to limit the usefulness of the model for evaluating effects of pumping in the coal-lease area. Use of the PWCC model by the NGS-KMC EIS team, however, should include evaluations of the effects of these artificial boundaries on calculated drawdown and capture in areas of interest.

Evaluation of the PWCC model (Tetra Tech, 2014) involved consideration of aspects of the model including the MODFLOW version used, model grid, time discretization, recharge, internal and perimeter boundary conditions, aquifer storage properties and hydraulic diffusivity, and model calibration. This evaluation found no problems with the PWCC model that would preclude its use by the NGS-KMC EIS team. Given the complexity of the N and D aquifer system in the study area and the amounts and types of data available, the calibration of the PWCC model described in Tetra Tech (2014) seems to be reasonable. Observed streamflow in most of the major washes is simulated reasonably well.

An evaluation of long-term effects of hypothetical pumping in the coal-lease area was carried out to understand possible timing of capture. An extended-pumping analysis simulated pumping wells in the coal-lease area for a period of 1,000 years. The effect evaluated was "global capture," which is the reduced groundwater discharge to all springs, streams, and evapotranspiration. A limited-pumping analysis also was carried out. For those simulations, wells in the coal-lease area were pumped for 80 years and then shut off. Global capture was calculated for the period during pumping and for a period of 1,000 years after pumping stopped. Both the extended and limited pumping analyses were run with the PWCC and USGS models for comparison of the timing of effects. The USGS model calculated faster capture in both cases, most likely because of the boundary conditions used to represent streams. For the limited-pumping analysis, the PWCC model indicates that maximum capture occurs about 30 years after pumping stops. If the intent of NGS-KMC EIS model runs is to determine maximum global capture from PWCC mine pumping, a post-pumping analysis period of 50–100 years likely would be sufficient.

For future models of the D and N aquifers in the Black Mesa area, use of time-varying recharge distributions calculated by BCM or another water-balance model would allow for better separation of climatic and human-caused effects on groundwater levels and flow in springs and streams. Use of time-varying recharge also could help in the calibration of aquifer storage properties.

Analyses of trends in water quality were carried out for select sites in the study area. Sites were selected where 5 years of specific-conductance, dissolved-solids, chloride, and sulfate data were available. These data were plotted over time to look for potential trends. Twenty-five well sites and four spring sites met the criteria and were analyzed for trends in sulfate, chloride, and total dissolved solids that could indicate induced leakage from the D aquifer to the N aquifer. Statistical analyses to determine if trends exist included simple linear regression and Kendall's tau. A total of 25 wells had sufficient data for analysis, and of those, water-quality data from 3 wells indicated appreciable trends for increased total dissolved solids, chloride, and sulfate. The remaining 22 wells had no statistically significant trends in these constituents. Of four springs that had sufficient water-quality data for analysis, only one was in an area subject to pumping-induced increased leakage of poorer quality water into the N aquifer. Data from that spring did not indicate a trend in total dissolved solids, chloride, and sulfate.

References Cited

Barlow, P.M., and Leake, S.A., 2012, Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow: U.S. Geological Survey Circular 1376, 84 p. [Also available at http://pubs.usgs.gov/circ/1376/.]

Brown, J.G., and Eychaner, J.H., 1988, Simulation of five ground-water withdrawal projections for the Black Mesa area, Navajo and Hopi Indian Reservations, Arizona: U.S. Geological Survey Water-Resources Investigations Report 88–4000, 51 p.

Cooley, M.E., Harshbarder, J.W., Akers, J.P., and Hardt, W.F., 1969, Regional hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah: U.S. Geological Survey Professional Paper 521-A, 61 p.

Doherty, J., 1998, PPEST— Parallel Parameter Estimation: Watermark Computing, Corinda, Australia, 122 p.

Doherty, J., 2013, Addendum to the PEST Manual: Watermark Computing, Corinda, Australia, 293 p.

Eychaner, J.H., 1983, Geohydrology and effects of water use in the Black Mesa area, Navajo and Hopi Indian Reservations, Arizona: U.S. Geological Survey Water-Supply Paper 2201, 26 p.

Flint, L.E., and Flint, A.L., 2008, Regional analysis of groundwater recharge, *in* Stonestrom, D.A., Constantz, J., Ferré, T.P.A., and Leake, S.A., eds., Groundwater recharge in the arid and semiarid southwestern United States: U.S. Geological Survey Professional Paper 1703, p. 29–59.

Harbaugh, A.W., 2005, MODFLOW-2005, the U.S. Geological Survey modular groundwater model—the Groundwater Flow Process: U.S. Geological Survey Techniques and Methods 6-A16, variously paginated.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW–2000, the U.S. Geological Survey Modular Ground-Water Model—User guide to modularization concepts and the Ground-Water Flow Process: U.S. Geological Survey Open-File Report 00–92, 121 p.

Harbaugh, A.W., and McDonald, M.G., 1996, A modular three-dimensional finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 96–485, 56 p.

HDR Engineering, Inc., 2003, Report of Findings for the assessment of Western Navajo-Hopi Water Supply Needs, Alternatives, and Impacts: HDR Engineering, Inc. for the Bureau of Reclamation.

Konikow, L.F., Hornberger, G.Z., Halford, K.J., and Hanson, R.T., 2009, Revised multi-node well (MNW2) package for MODFLOW ground-water flow model: U.S. Geological Survey Techniques and Methods 6–A30, 67 p.

Lopes, T.J., and Hoffmann, J.P., 1997, Geochemical analyses of ground-water ages, recharge rates, and hydraulic conductivity of the N Aquifer, Black Mesa area, Arizona: U.S. Geological Survey Water-Resources Investigations Report 96–4190, 42 p.

Macy, J.P., and Unema, J.A., 2014, Groundwater, surface-water, and water chemistry data, Black Mesa area, northeastern Arizona—2011–2012: U.S. Geological Survey Open-File Report 2014–1304, 42 p.

Niswonger, R.G., Panday, Sorab, and Ibaraki, Motomu, 2011, MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6–A37, 44 p.

Niswonger, R.G., and Prudic, D.E., 2005, Documentation of the Streamflow-Routing (SFR2) Package to include unsaturated flow beneath streams—A modification to SFR1: U.S. Geological Survey Techniques and Methods 6-A13, 50 p.

Peabody Western Coal Company, Inc., 1999, A three-dimensional flow model of the D and N aquifers, Black Mesa Basin, Arizona: Consulting report prepared by HSI/Geotrans, Inc. and Waterstone Engineering, Inc. for Peabody Western Coal Company, three volumes.

Prudic, D.E., Konikow, L.F., and Banta, E.R., 2004, A new Streamflow-Routing (SFR1) Package to simulate stream-aquifer interaction with MODFLOW–2000: U.S. Geological Survey Open-File Report 2004–1042, 95 p.

Reilly, T.E., and Harbaugh, A.W., 2004, Guidelines for evaluating ground-water flow models: U.S. Geological Survey Scientific Investigations Report 2004–5038, 30 p.

Tetra Tech, Inc., 2014, Update of Peabody Western Coal Company's Groundwater Flow Model of the N and D Aquifers, Northeastern Arizona Version 1.0: prepared for Peabody Western Coal Company, Tetra Tech, Inc., Louisville, Colo., 115 p.

Thomas, B.E., 2002, Ground-water, surface-water, and water-chemistry data, Black Mesa area, Northeastern Arizona—2000–2001, and performance and sensitivity of the 1988 USGS numerical model of the N Aquifer: U.S. Geological Survey Water-Resources Investigations Report 02–4211, 76 p.

Truini, Margot, and Longsworth, S.A., 2003, Hydrogeology of the D aquifer and movement and ages of ground water determined from geochemical and isotopic analyses, Black Mesa area, northeastern Arizona: U.S. Geological Survey Water-Resources Investigations Report 03–4189, 38 p.

Truini, Margot, and Macy, J.P., 2005, Lithology and thickness of the Carmel Formation as related to leakage between the D and N aquifer, Black Mesa, Arizona: U.S. Geological Survey Scientific Investigations Report 2005–5187, 7 p.

Appendix. U.S. Geological Survey Black Mesa Monitoring Reports

Year Published	Author(s)	Title	USGS Report Type and Number
1978	U.S. Geological Survey	Progress report on Black Mesa monitoring program—1977	Open-File Report 78–459
1985	Hill, G.W.	Progress report on Black Mesa monitoring program—1984	Open-File Report 85-483
1986	Hill, G.W., and Whetten, M.I.	Progress report on Black Mesa monitoring program—1985–86	Open-File Report 86-414
1987	Hill, G.W., and Sottilare, J.P.	Progress report on the ground-water, surface-water, and quality-of-water monitoring program, Black Mesa area, northeastern Arizona—1987	Open-File Report 87–458
1988	Hart, R.J., and Sottilare, J.P.	Progress report on the ground-water, surface-water, and quality-of-water monitoring program, Black Mesa area, northeastern Arizona—1987–88	Open-File Report 88–467
1989	Hart, R.J., and Sottilare, J.P.	Progress report on the ground-water, surface-water, and quality-of-water monitoring program, Black Mesa area, northeastern Arizona—1988–89	Open-File Report 89–383
1992	Sottilare, J.P.	Results of ground-water, surface-water, and water-quality monitoring, Black Mesa area, northeastern Arizona—1989–90	Water-Resources Investigations Report 92–4008
1992	Littin, G.R.	Results of ground-water, surface-water, and water-quality monitoring, Black Mesa area, northeastern Arizona—1990–91	Water-Resources Investigations Report 92–4045
1993	Littin, G.R.	Results of ground-water, surface-water, and water-quality monitoring, Black Mesa area, northeastern Arizona—1991–92	Water-Resources Investigations Report 93–4111
1995	Littin, G.R., and Monroe, S.A.	Results of ground-water, surface-water, and water-quality monitoring, Black Mesa area, northeastern Arizona—1992–93	Water-Resources Investigations Report 95–4156
1995	Littin, G.R., and Monroe, S.A.	Results of ground-water, surface-water, and water-chemistry monitoring, Black Mesa area, northeastern Arizona—1994	Water-Resources Investigations Report 95–4238
1996	Littin, G.R., and Monroe, S.A.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—1995	Open-File Report 96–616
1997	Littin, G.R., and Monroe, S.A.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—1996	Open-File Report 97–566
1999	Littin, G.R., Baum, B.M., and Truini, Margot	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—1997	Open-File Report 98–653
2000	Truini, Margot, Baum, B.M., Littin, G.R., and Shingoitewa-Honanie, Gayl	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—1998	Open-File Report 00–66
2000	Thomas, B.E., and Truini, Margot	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona–1999	Open-File Report 00–453
2002	Thomas, B.E.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2000–2001, and performance and sensitivity of the 1988 USGS numerical model of the N aquifer	Water-Resources Investigations Report 02–4211
2002	Thomas, B.E.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2001–02	Open-File Report 02–485
2004	Truini, Margot, and Thomas, B.E.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2002–03	Open-File Report 03–503
2005	Truini, Margot, Macy, J.P., and Porter T.J.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2003–04	Open-File Report 2005–1080
2006	Truini, Margot, and Macy, J.P.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2004–05	Open-File Report 2006–1058
2007	Truini, Margot, and Macy, J.P.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2005–06	Open-File Report 2007–1041
2008	Truini, Margot, and Macy, J.P.	Ground-water, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2006–07	Open-File Report 2008–1324
2009	Macy, Jamie P.	Groundwater, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2007–2008	Open-File Report 2009–1148
2010	Macy, Jamie P.	Groundwater, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2008–2009	Open-File Report 2010–1038
2011	Macy, Jamie P., and Brown, C.R.	Groundwater, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2009–2010	Open-File Report 2011-1198
2012	Macy, Jamie P., Brown, C.R., and Anderson, J.R.	Groundwater, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2010–2011	Open-File Report 2012-1102
2014	Macy, Jamie P. and Unema, Joel A.	Groundwater, surface-water, and water-chemistry data, Black Mesa area, northeastern Arizona—2011–2012	Open-File Report 2013-1304

Menlo Park Publishing Service Center, California
Manuscript approval date May 25, 2016
Edited by Katherine Jacques
Design and layout by Vivian Nguyen

USGS

Leake, Macy, and Truini—**Hydrologic Analyses In Support of the Navajo Generating Station-Kayenta Mine Complex**—Open-File Report 2016–1088

ISSN 2331-1258 (online)

Appendix 3.8-A

State-designated Noxious Weeds – Arizona, Nevada, and Utah

This page intentionally left blank

Arizona

This page intentionally left blank

TITLE 3. AGRICULTURE

CHAPTER 4. DEPARTMENT OF AGRICULTURE PLANT SERVICES DIVISION

Authority: A.R.S. §§ 3-107, 3-201 et seq., 3-441 et seq., and 3-481 et seq.

Title 3, Chapter 4, Article 1, Sections R3-4-101 through R3-4-109 renumbered from Title 3, Chapter 1, Article 1, Sections R3-1-01 through R3-1-09; Title 3, Chapter 4, Article 2, Sections R3-4-201 through R3-4-248 renumbered from Title 3, Chapter 1, Article 2, Sections R3-1-50 through R3-1-77; Title 3, Chapter 4, Article 3, Sections R3-4-301 through R3-4-307 renumbered from Title 3, Chapter 1, Article 3, Sections R3-1-301 through R3-1-307; Title 3, Chapter 4, Article 4, Sections R3-4-401 through R3-4-408 renumbered from Title 3, Chapter 1, Article 4, Sections R3-1-401 through R3-1-408; Title 3, Chapter 4, Article 5, Sections R3-4-501 through R3-4-504 renumbered from Title 3, Chapter 1, Article 5, Sections R3-1-501 through R3-1-504; Title 3, Chapter 4, Article 6, Sections R3-4-601 through R3-4-633 and Appendix 1 renumbered from Title 3, Chapter 1, Article 6, Sections R3-1-601 through R3-1-633 and Appendix 1; Title 3, Chapter 4, Article 7, Sections R3-4-701 through R3-4-708 renumbered from Title 3, Chapter 7, Article 1, Sections R3-7-101 through R3-7-108; Title 3, Chapter 4, Article 8, Sections R3-4-801 through R3-4-807 renumbered from Title 3, Chapter 7, Article 2, Sections R3-7-201 through R3-7-207 (Supp. 91-4).

ARTICLE 1. GENERAL PROVISIONS

Title 3, Chapter 4, Article 1, Sections R3-4-101 through R3-4-109 renumbered from Title 3, Chapter 1, Article 1, Sections R3-1-01 through R3-1-09 (Supp. 91-4).

Section
R3-4-101. Definitions
R3-4-102. Licensing Time-frames
R3-4-103. Repealed
R3-4-104. Repealed
R3-4-105. Repealed
R3-4-106. Repealed
R3-4-107. Repealed
R3-4-108. Repealed
R3-4-109. Repealed
Table 1. Time-frames (Calendar Days)

ARTICLE 2. QUARANTINE

Title 3, Chapter 4, Article 2, Sections R3-4-201 through R3-4-248 renumbered from Title 3, Chapter 1, Article 2, Sections R3-1-50 through R3-1-77 (Supp. 91-4).

Section
R3-4-201. Definitions
R3-4-202. Transportation and Packaging
R3-4-203. Repealed
R3-4-204. Boll Weevil and Pink Bollworm Pests: Interior Quarantine
R3-4-205. Renumbered
R3-4-206. Repealed
R3-4-207. Repealed
R3-4-208. Repealed
R3-4-209. Repealed
R3-4-210. Repealed
R3-4-211. Repealed
R3-4-212. Repealed
R3-4-213. Repealed
R3-4-214. Repealed
R3-4-215. Repealed
R3-4-216. Repealed
R3-4-217. Repealed
R3-4-218. Boll Weevil and Pink Bollworm Pests: Exterior Quarantine
R3-4-219. Citrus Fruit Surface Pest
R3-4-220. Citrus Nursery Stock Pests
R3-4-221. Repealed
R3-4-222. Repealed
R3-4-223. Repealed
R3-4-224. Repealed
R3-4-225. Repealed
R3-4-226. Scale Insect Pests
R3-4-227. Repealed
R3-4-228. European Corn Borer
R3-4-229. Nut Tree Pests
R3-4-230. Repealed
R3-4-231. Nut Pests
R3-4-232. Repealed
R3-4-233. Lettuce Mosaic Virus
R3-4-234. Nematode Pests
R3-4-235. Repealed
R3-4-236. Repealed
R3-4-237. Repealed
R3-4-238. Whitefly Pests
R3-4-239. Imported Fire Ants
R3-4-240. Apple Maggot and Plum Curculio
R3-4-241. Lethal Yellowing of Palms
R3-4-242. Brown Citrus Aphid
R3-4-243. Repealed
R3-4-244. Regulated and Restricted Noxious Weeds
R3-4-245. Prohibited Noxious Weeds
R3-4-246. Caribbean Fruit Fly
R3-4-247. Repealed
R3-4-248. Japanese beetle

ARTICLE 3. NURSERY CERTIFICATION PROGRAM

Title 3, Chapter 4, Article 3, Sections R3-4-301 through R3-4-307 renumbered from Title 3, Chapter 1, Article 3, Sections R3-1-301 through R3-1-307 (Supp. 91-4).

Article 3 consisting of Sections R3-4-301 through R3-4-307 adopted effective January 17, 1989.

Section
R3-4-301. Nursery Certification
R3-4-302. Repealed
R3-4-303. Repealed
R3-4-304. Repealed
R3-4-305. Repealed
R3-4-306. Repealed
R3-4-307. Repealed

ARTICLE 4. SEEDS

Title 3, Chapter 4, Article 4, Sections R3-4-401 through R3-4-408 renumbered from Title 3, Chapter 1, Article 4, Sections R3-1-401 through R3-1-408 (Supp. 91-4).

Article 4 consisting of Sections R3-4-110 through R3-4-117 renumbered without change as Article 4, Sections R3-4-401 through R3-4-408 (Supp. 89-1).

Section
R3-4-401. Definitions
R3-4-402. Labeling
R3-4-403. Noxious Weed Seeds
R3-4-404. Germination Standards

R3-4-405. Seed-certifying Agencies
R3-4-406. Sampling and Analyzing Seed
R3-4-407. Phytosanitary Field Inspection; Fee
R3-4-408. Licenses: Seed Dealer and Seed Labeler; Fees
R3-4-409. Violations and Penalties

ARTICLE 5. COLORED COTTON

(Authority: A.R.S. § 3-205.02 et seq.)

Article 5, consisting of Section R3-4-501 renumbered from R3-4-205 and amended, effective April 9, 1998 (Supp. 98-2).

Article 5, consisting of Sections R3-4-501 through R3-4-506, repealed by summary action with an interim effective date of February 10, 1995; interim effective date of February 10, 1995 now the permanent date (Supp. 96-3).

Article 5, consisting of Sections R3-4-501 through R3-4-505 adopted effective October 15, 1993 (Supp. 93-4).

Article 5, consisting of Sections R3-4-501 through R3-4-504 repealed effective October 15, 1993 (Supp. 93-4).

Title 3, Chapter 4, Article 5, Sections R3-4-501 through R3-4-504 renumbered from Title 3, Chapter 1, Article 5, Sections R3-1-501 through R3-1-504 (Supp. 91-4).

Article 5 consisting of Sections R3-4-120 through R3-4-122 renumbered without change as Article 5, Sections R3-4-501 through R3-4-503 (Supp. 89-1).

Section
R3-4-501. Colored Cotton Production and Processing

ARTICLE 6. RECODIFIED

Article 6, consisting of Sections R3-4-601 through R3-4-611 and Appendix A, recodified to 3 A.A.C. 3, Article 11 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

Article 6, consisting of Sections R3-4-601 through R3-4-618 and Appendix A, adopted effective July 6, 1993 (Supp. 93-3).

Article 6, consisting of Sections R3-4-601 through R3-4-633 and Appendix A, repealed effective July 6, 1993 (Supp. 93-3).

Title 3, Chapter 4, Article 6, Sections R3-4-601 through R3-4-633 and Appendix 1 renumbered from Title 3, Chapter 1, Article 6, Sections R3-1-601 through R3-1-633 and Appendix 1.

Article 6 consisting of Sections R3-4-130 through R3-4-141 renumbered without change as Article 6, Sections R3-4-601 through R3-4-612 (Supp. 89-1).

Section
R3-4-601. Recodified
R3-4-602. Recodified
R3-4-603. Recodified
R3-4-604. Recodified
R3-4-605. Recodified
R3-4-606. Recodified
R3-4-607. Recodified
R3-4-608. Recodified
R3-4-609. Recodified
R3-4-610. Recodified
R3-4-611. Recodified
R3-4-612. Repealed
R3-4-613. Repealed
R3-4-614. Repealed
R3-4-615. Repealed
R3-4-616. Renumbered
R3-4-617. Repealed
R3-4-618. Renumbered
R3-4-619. Repealed
R3-4-620. Repealed
R3-4-621. Repealed
R3-4-622. Repealed
R3-4-623. Repealed
R3-4-624. Repealed
R3-4-625. Repealed
R3-4-626. Repealed
R3-4-627. Repealed
R3-4-628. Repealed
R3-4-629. Repealed
R3-4-630. Repealed
R3-4-631. Repealed
R3-4-632. Repealed
R3-4-633. Repealed
Appendix A. Recodified

ARTICLE 7. FRUIT AND VEGETABLE STANDARDIZATION

(Authority: A.R.S. § 3-481 et seq.)

Title 3, Chapter 4, Article 7, Sections R3-4-701 through R3-4-708 renumbered from Title 3, Chapter 7, Article 1, Sections R3-7-101 through R3-7-108 (Supp. 91-4).

Section
R3-4-701. Apple Standards
R3-4-702. Apricot Standards
R3-4-703. Asparagus Standards
R3-4-704. Beet and Turnip Standards
R3-4-705. Broccoli Standards
R3-4-706. Brussels Sprouts Standards
R3-4-707. Cabbage Standards
R3-4-708. Cantaloupe Standards; Maturity Sampling; Packing Arrangements
R3-4-709. Carrot Standards
R3-4-710. Cauliflower Standards
R3-4-711. Celery Standards
R3-4-712. Cherry Standards
R3-4-713. Corn Standards
R3-4-714. Endive, Escarole, or Chicory Standards
R3-4-715. Greens Standards (Collard, Rapini, Mustard, and Turnip)
R3-4-716. Head Lettuce Standards
R3-4-717. Melon Standards (Persian Melons, Casabas, Crenshaw, Honeydew, Honeyball, Other Specialty Melons, and Watermelons); Maturity Sampling
R3-4-718. Nectarine Standards
R3-4-719. Okra Standards
R3-4-720. Dry Onion Standards
R3-4-721. Pea Standards
R3-4-722. Peach Standards
R3-4-723. Pear Standards
R3-4-724. Sweet Pepper Standards
R3-4-725. Fresh Plum and Prune Standards
R3-4-726. Potato Standards
R3-4-727. Romaine Standards
R3-4-728. Spinach Standards
R3-4-729. Strawberry Standards
R3-4-730. String Bean Standards
R3-4-731. Summer Squash Standards
R3-4-732. Sweet Potato Standards
R3-4-733. Table Grape Standards
R3-4-734. Tomato Standards
R3-4-735. Winter Squash Standards
R3-4-736 Standards for Unlisted Fresh Fruits and Vegetables, Experimental Product Standards

R3-4-737. Container Labeling for Fruit and Vegetables
R3-4-738. Inspection and Representative Sampling for Fruit and Vegetables
R3-4-739. Reconditioning for Fruit and Vegetables
R3-4-740. Experimental Pack and Product Permits for Fruit and Vegetables
R3-4-741. Inspection Fee
R3-4-742. Recordkeeping and Reporting Requirements for Fruit and Vegetable Commission Merchants
R3-4-743. Recordkeeping and Reporting Requirements for Fruit and Vegetable Shippers

ARTICLE 8. CITRUS FRUIT STANDARDIZATION

(Authority: A.R.S. § 3-441 et seq.)

Title 3, Chapter 4, Article 8, Sections R3-4-801 through R3-4-807 renumbered from Title 3, Chapter 7, Article 2, Sections R3-7-201 through R3-7-207 (Supp. 91-4).

Section
R3-4-801. Orange and Grapefruit Standards
R3-4-802. Lemon Standards
R3-4-803. Lime Standards
R3-4-804. Tangerine, Tangelo, and Mandarin Standards
R3-4-805. Serious Defects in Citrus Fruit
R3-4-806. Tolerance for Serious Defects
R3-4-807. Freezing Damage
R3-4-808. Standards for Unlisted Citrus Fruit, Experimental Product Standards
R3-4-809. Bulk Sale of Citrus Fruit; Non-licensed Purchaser
R3-4-810. Packaged Count and Average Diameter
R3-4-811. Container Labeling for Citrus Fruit
R3-4-812. Inspections and Representative Sampling for Citrus Fruit
R3-4-813. Reconditioning for Citrus Fruit
R3-4-814. Experimental Pack and Product Permits for Citrus Fruit
R3-4-815. Recordkeeping and Reporting Requirements for Citrus Fruit Commission Merchants
R3-4-816. Recordkeeping and Reporting Requirements for Citrus Fruit Shippers

ARTICLE 9. BIOTECHNOLOGY

Article 9, consisting of Section R3-4-901, adopted effective November 22, 1993 (Supp. 93-4).

Section
R3-4-901. Genetically Engineered Organisms and Products

ARTICLE 1. GENERAL PROVISIONS

R3-4-101. Definitions

In addition to the definitions provided in A.R.S. §§ 3-201, 3-231, 3-441, and 3-481, the following definitions apply to this Chapter:

"Appliance" means any box, tray, container, ladder, tent, vehicle, implement, or any article or thing that is or may be used in growing, harvesting, handling, packing, or transporting any agricultural commodity.

"Aquatic" means living or growing in or on water.

"Bulk container" means a container used solely for transporting a commodity in bulk quantities.

"Carrier" means any plant or thing that can transport or harbor a plant pest.

"Certificate" means an original document issued by the Department, the United States Department of Agriculture, or authorized officer of the state of origin, stating name, quantity, and nature of the regulated commodity, and the information required by a specific regulation.

"Commodity" means any plant, produce, soil, material, or thing that may be subject to federal and state laws and rules.

"Container" means any box, crate, lug, chest, basket, carton, barrel, keg, drum, can, sack, or other receptacle for a commodity.

"Cotton lint" means the remnant produced when cottonseed is processed in a gin.

"Cotton plant" means all parts of *Gossypium* spp. whether wild or domesticated, except manufactured cotton products.

"Cotton products" include seed cotton, cotton lint, cotton linters, motes, cotton waste, gin trash, cottonseed, and cotton hulls.

"Cotton stubble" means the basal part of a cotton plant that remains attached to the soil after harvest.

"Cotton waste" includes all waste products from the processing of cotton at gins and cottonseed-oil mills, in any form or under any trade designation.

"Defoliate" means to remove the leaves from a plant.

"Diseased" means an abnormal condition of a plant resulting from an infection.

"Gin trash" means organic waste or materials resulting from ginning cotton.

"Head leaves" means all leaves that enfold the compact portion of a head of lettuce or cabbage.

"Host" means a plant on or in which a pest can live or reproduce, or both.

"Husk" means the membranous outer envelope of many seeds and fruit, such as an ear of corn or a nut.

"Infested" means any plant or other material on or in which a pest is found.

"Inspector" means an employee of the Department or other governmental agency who enforces any law or rule of the Department.

"Label" means all tags and other written, printed, or graphic representations in any form, accompanying or pertaining to a plant or other commodity.

"Lot" means any one group of plants or things, whether or not containerized that is set apart or is separate from any other group.

"Nursery" means real property or other premises on or in which nursery stock is propagated, grown, or cultivated or from which source nursery stock is offered for distribution or sale. (A.R.S. § 3-201(5))

"Permit" means an official document authorizing the movement of a host plant and carrier.

"Person" means an individual, partnership, corporation, association, governmental subdivision or unit of a governmental subdivision, a public or private organization of any character, or another agency.

"Plant" or "crop" includes every kind of vegetation, wild or domesticated, and any part thereof, as well as seed, fruit or other natural product of such vegetation. (A.R.S. § 3-201(8))

"Reshipment" means the shipment of a commodity after receipt from another shipping point.

"Sell" means to exchange for money or its equivalent including to offer, expose, or possess a commodity for sale or to otherwise exchange, barter, or trade.

"Serious damage" means any injury or defect rising from any circumstance, natural or mechanical, that affects the appearance or the edible or shipping quality of a commodity, or lot.

"Soil" means any non-liquid combination of organic, or organic and inorganic material in which plants can grow.

"Stub or soca cotton" means cotton stalks of a previous crop that begin to show signs of growth.

"Subcontainer" means any container being used within another container.

"Transport" means moving an article from one point to another.

"Treatment" means an application of a substance as either a spray, mist, dust, granule, or fumigant; or a process in which a substance or procedure is used to control or eradicate a plant pest.

"Vector" means an organism (usually an insect) that may carry a pathogen from one host plant to another.

"Vehicle" means an automotive device, such as a car, bus, truck, or private or recreational vehicle.

"Volunteer cotton" means a sprout from seed of a previous crop.

"Wrapper leaves" means all leaves that do not closely enfold the compact portion of the head of lettuce or cabbage.

Historical Note

Former Rule 1; Amended effective June 16, 1977 (Supp. 77-3). Section R3-1-01 renumbered to R3-4-101 (Supp. 91-4). Repealed effective April 11, 1994 (Supp. 94-2). New Section R3-4-101 renumbered from R3-4-102 without change, effective October 8, 1998 (Supp. 98-4). Amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Amended by final rulemaking at 19 A.A.R. 3860, effective January 4, 2014 (Supp. 13-4).

R3-4-102. Licensing Time-frames

A. Overall time-frame. The Department shall issue or deny a license within the overall time-frames listed in Table 1 after receipt of the complete application. The overall time-frame is the total of the number of days provided for the administrative completeness review and the substantive review.

B. Administrative completeness review.

1. The administrative completeness review time-frame established in Table 1 begins on the date the Department receives the application. The Department shall notify the applicant in writing within the administrative completeness review time-frame whether the application or request is incomplete. The notice shall specify what information is missing. If the Department does not provide notice to the applicant within the administrative completeness review time-frame, the Department considers the application complete.
2. An applicant with an incomplete license application shall supply the missing information within the completion request period established in Table 1. The administrative completeness review time-frame is suspended from the date the Department mails the notice of missing information to the applicant until the date the Department receives the information.
3. If the applicant fails to submit the missing information before the expiration of the completion request period, the Department shall close the file, unless the applicant requests an extension. An applicant whose file has been closed may obtain a license by submitting a new application.

C. Substantive review. The substantive review time-frame established in Table 1 shall begin after the application is administratively complete.

1. If the Department makes a comprehensive written request for additional information, the applicant shall submit the additional information identified by the request within the additional information period provided in Table 1. The substantive review time-frame is suspended from the date of the Department request until the information is received by the Department. If the applicant fails to provide the information identified in the written request within the additional information period, the Department shall deny the license.
2. The Department shall issue a written notice granting or denying a license within the substantive review time-frame. If the application is denied, the Department shall send the applicant written notice explaining the reason for the denial with citations to supporting statutes or rules, the applicant's right to seek a fair hearing, and the time period in which the applicant may appeal the denial.

Historical Note

Former Rule 2; Amended effective June 19, 1978 (Supp. 78-3). Section R3-1-02 renumbered to R3-4-102 (Supp. 91-4). Section repealed, new Section adopted effective January 6, 1994 (Supp. 94-1). Section R3-4-102 renumbered to R3-4-101; new Section R3-4-102 adopted effective October 8, 1998 (Supp. 98-4).

R3-4-103. Repealed

Historical Note

Former Rule 3. Section R3-1-03 renumbered to R3-4-103 (Supp. 91-4). Repealed effective September 22, 1994 (Supp. 94-3).

R3-4-104. Repealed

Historical Note

Former Rule 4. Section R3-1-04 renumbered to R3-4-104 (Supp. 91-4). Repealed effective September 22, 1994 (Supp. 94-3).

R3-4-105. Repealed

Historical Note

Former Rule 5. Section R3-1-05 renumbered to R3-4-105 (Supp. 91-4). Amended effective September 22, 1994 (Supp. 94-3). Section repealed by final rulemaking at 6 A.A.R. 41, effective December 8, 1999 (Supp. 99-4).

R3-4-106. Repealed

Historical Note

Former Rule 6. Section R3-1-06 renumbered to R3-4-106 (Supp. 91-4). Repealed effective September 22, 1994 (Supp. 94-3).

R3-4-107. Repealed

Historical Note

Former Rule 7. Section R3-1-07 renumbered to R3-4-107 (Supp. 91-4). Amended effective September 22, 1994

(Supp. 94-3). Section repealed by final rulemaking at 19 A.A.R. 3860, effective January 4, 2014 (Supp. 13-4).

R3-4-108. Repealed

Historical Note

Former Rule 8. Section R3-1-08 renumbered to R3-4-108 (Supp. 91-4). Repealed effective September 22, 1994 (Supp. 94-3).

R3-4-109. Repealed

Historical Note

Former Rule 9. Section R3-1-09 renumbered to R3-4-109 (Supp. 91-4). Repealed effective September 22, 1994 (Supp. 94-3).

Table 1. Time-frames (Calendar Days)

License	Authority	Administrative Completeness Review	Response to Completion Request	Substantive Completeness Review	Response to Additional Information	Overall Time-frame
QUARANTINE						
Boll Weevil and Pink Bollworm	R3-4-204(D)	14	14	30	30	44
Small-Grain Crop Approval	R3-4-204(E)(4)(b)	14	14	30	30	44
Boll Weevil and Pink Bollworm	R3-4-218	14	14	30	30	44
Citrus Fruit Surface Pest	R3-4-219	14	14	60	30	74
European Corn Borer	R3-4-228	14	14	30	30	44
Lettuce Mosaic	R3-4-233	14	14	30	30	44
Noxious Weeds Regulated and Restricted Prohibited	R3-4-244 R3-4-245	14	14	30	30	44
Plum Curculio and Apple Maggot	R3-4-240	14	14	60	30	74
Colored Cotton	A.R.S. § 3-205.02 R3-4-501	14	0	0	0	14
NURSERY						
General Nursery Stock Inspection	R3-4-301(B)	30	14	1 yr	14	1 yr, 30 days
Special Nursery Stock Inspection: Ozonium Root Rot • Method of Growing New Renewal • Indicator Crop Planted on Applicant's Property	R3-4-301(C)	7 7 7	14 14 14	60 30 4 yrs	14 14 14	67 37 4 yrs, 7 days
Special Nursery Stock Inspection: Rose Mosaic	R3-4-301(C)	7	14	180	14	187
Special Nursery Stock Inspection: Brown Garden Snail	R3-4-301(C)	7	14	30	14	37
Special Nursery Stock Inspection: Other	R3-4-301(C)	7	14	30	14	37
Phytosanitary Field Inspection	A.R.S. § 3-233(A)(7) R3-4-407	30	7	210	7	240
STANDARDIZATION						
Experimental Pack and Product for Fruit and Vegetables	A.R.S. § 3-487 R3-4-740	7	7	7	7	14

Experimental Pack and Product for Citrus Fruit	A.R.S. § 3-445 R3-4-814	7	7	7	7	14
Citrus Fruit Dealer, Packer, or Shipper License	A.R.S. § 3-449	14	14	14	14	28
Fruit and Vegetable Dealer, Packer, or Shipper License	A.R.S. § 3-492	14	14	14	14	28
SEED DEALERS AND LABELERS						
Seed Dealer	A.R.S. § 3-235 R3-4-408	14	14	14	14	28
Seed Labeler	A.R.S. § 3-235 R3-4-408	14	14	14	14	28

Historical Note

Table 1 adopted effective October 8, 1998 (Supp. 98-4). Amended by final rulemaking at 7 A.A.R. 3812, effective August 10, 2001 (Supp. 01-3). Amended by final rulemaking at 8 A.A.R. 3633, effective August 7, 2002 (Supp. 02-3). Amended by final rulemaking at 8 A.A.R. 4454, effective October 2, 2002 (Supp. 02-4). Amended Section references under Arizona Native Plants to correspond to recodification at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1). Amended by final rulemaking at 10 A.A.R. 2665, effective June 8, 2004 (Supp. 04-2). Amended by final rulemaking at 19 A.A.R. 3860, effective January 4, 2014 (Supp. 13-4).

ARTICLE 2. QUARANTINE

R3-4-201. Definitions

The following definitions apply to this Article:

"Associate Director" means the Associate Director of the Plant Services Division.

"Common carrier" means any person transporting a commodity or appliance for compensation or commercial purpose.

"Compliance agreement" means a written agreement or permit between a person and the Department for the purpose of allowing the movement or production of a regulated commodity or appliance from a quarantined area of this state and containing demonstrated safeguarding measures to ensure compliance with the purposes of A.R.S. Title 3, Chapter 2, Article 1.

"Consumer container" means a container that is produced or distributed for retail sale or for consumption by an individual.

"Cotton harvesting machine" means any machine used to pick or harvest raw cotton in a field.

"Designated treatment area" means an area temporarily approved by the Department for the holding and treatment of a commodity or appliance for a pest in cases where a quarantine holding area does not exist.

"Epiphytically" means the function of a plant growing on another plant or object but that does not require the other plant or object as a source of nutrients.

"Fumigate" means to apply a gaseous substance to a commodity or appliance in a closed area to eradicate a pest.

"Hull" means the dry outer covering of a seed or nut.

"Infected" means any plant or other material on or in which a disease is found.

"Limited permit" means a permit issued by the Department to a common carrier or responsible party to transport a commodity or appliance that would otherwise be restricted.

"Master permit" means a permit issued by the Department to another state department of agriculture that gives that other state authority to certify, in accordance with the terms of the permit, that a regulated commodity or appliance may enter Arizona without a quarantine compliance certificate.

"Origin inspection agreement" means a permit issued by the Department to a person that specifies terms to ship or transport a regulated commodity or appliance into Arizona, which importation would otherwise be prohibited by this Article, and that the origin state department of agriculture agrees with.

"Package" means (i) any box, bag, or envelope used for the shipment of a commodity or appliance through postal and parcel services or (ii) individual packets of seeds for planting.

"Pest free" means apparently free from all regulated plant pests, as determined by an inspection.

"Phytosanitary certificate" means a certificate issued by a regulatory official for the purpose of certifying a commodity or appliance as pest free.

"Private carrier" means any person transporting a commodity or appliance for a noncommercial purpose.

"Quarantine compliance certificate" means a certificate issued by a plant regulatory official of the originating state that establishes that a commodity or appliance has been treated or inspected to comply with Arizona quarantine rules and orders and includes a certificate of inspection.

"Receiver" means any person or place of business listed on a bill of lading, manifest, or freight bill as a consignee or destination for a commodity or appliance.

"Regulated plant pest" means all live life stages of an arthropod, disease, plant, nematode, or snail that is regulated or considered under quarantine by a state or federal law, rule or order enforced by the Department.

"Responsible party" means a common carrier, person, or place of business that is legally responsible for the possession of a commodity or appliance.

"Treatment Manual" means the USDA-APHIS-PPQ Treatment Manual, T301—Cotton and Cotton Products, revised March 2013. The Treatment Manual is incorporated by reference, does not include any later amendments or editions, and is available from the Department and online at http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf.

Historical Note

Former Rule, Quarantine Regulation 2; Amended effective July 1, 1975 (Supp. 75-1). Former Section R3-4-50 repealed, new Section R3-4-50 adopted effective October 23, 1978 (Supp. 78-5). Section R3-1-50 renumbered to

R3-4-201 (Supp. 91-4). Section repealed; new Section adopted by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Amended by final rulemaking at 19 A.A.R. 3860, effective January 4, 2014 (Supp. 13-4).

R3-4-202. Transportation and Packaging

A. Any commodity shipped or transported into the state shall be inspected to determine whether the commodity is free of all pests subject to federal and state laws and rules.

B. Each commodity shipped or transported into the state shall display the following information on a bill of lading, manifest, freight bill, or on the outside of the carton;
1. The name and address of the shipper and receiver;
2. A certificate of inspection for nursery stock, if applicable;
3. The botanical or common name of the commodity;
4. The quantity of each type of commodity;
5. The state or foreign country where each commodity originated;
6. Any other certificate required by this Article.

C. Packaging.
1. Any commodity shipped or transported into the state shall be packaged or wrapped in a manner to allow inspection by an inspector.
2. The following and other similar types of packages are prohibited:
   a. Packages that cannot be opened without destroying either the package or its contents;
   b. Packages that cannot, once opened, be resealed after inspection without the inspector supplying additional packing material to protect the contents;
   c. Commodities that are packaged or sealed with wire or seals that cannot be opened and resealed without special tools or equipment;
   d. Clear or colored waxes applied to a commodity that prevent inspection.

D. Restrictions.
1. Nursery stock shipments shall not enter Arizona between 8:00 a.m. Friday and 12:01 a.m. Monday, or during a legal holiday.
2. Common and private carriers. A carrier shall declare all commodities at a port-of-entry.
   a. All carriers shall hold a commodity until it is inspected by an inspector and a Certificate of Release, under A.R.S. § 3-209, is issued. The Director may authorize a carrier to deliver a commodity to a consignee before the inspection.
      i. If the commodity requiring inspection cannot be adequately inspected, the inspector may place the commodity under a "Warning-Hold for Agricultural Inspection."
      ii. The inspector may seal the truck to prevent the likelihood of spreading harmful pests.
   b. When a carrier enters the state at a port-of-entry where agriculture inspections are performed, the driver shall:
      i. Provide the inspector with the bill of lading, manifest, or a short-form manifest signed by the company's authorized agent responsible for supervising the loading of the contents in the shipment;
      ii. Open the vehicle and expose the contents for inspection; and
      iii. Assist the inspector in gaining access to the contents.
   c. When a carrier enters the state at a port-of-entry where no agricultural inspections are performed, the carrier shall follow procedures specified in subsection (D)(2)(b), proceed to destination for inspection, and provide the following information on a Load Report form:
      i. The name, address, and telephone number of the shipper;
      ii. The name, address, and telephone number of the primary receiver;
      iii. The name and address of the carrier;
      iv. The tractor unit number and trailer license number; and
      v. The name and address of additional receivers, if any.
3. Bulk mail facility. All commodities entering a bulk mail facility shall be held for inspection. The commodity shall not be released until an inspector inspects the commodity and issues a Certificate of Release.
4. Railroad. Any commodity shipped by railroad shall be inspected at destination. The responsible party shall notify the Director in advance of the shipment to schedule an inspection of the commodity.
5. Out-of-state destination. If a commodity requiring inspection is shipped to a point outside the state, and is confirmed by a short-form manifest, freight bill, or bill of lading, the inspector shall give the driver a notice in writing, or by transit stamp, that the shipment is under quarantine while in the state, and it is unlawful to dispose of the shipment in any way unless the shipment is inspected and released by an inspector.
6. Certificate of Release. Any person receiving a commodity from a post office, United Parcel Service terminal, or any carrier without a Certificate of Release shall immediately notify the Department and request an inspection.

E. Disposition of commodity. When a carrier is in possession of, or responsible for, a commodity inspected by an inspector and found in violation of Arizona quarantine laws, and elects to ship the commodity out-of-state:
1. The inspector shall issue a "Warning-Hold for Agricultural Inspection" notice to the carrier. The carrier shall hold the notice until the commodity is removed from the state through a port-of-entry designated by the inspector and the removal is noted on the notice.
2. The carrier shall surrender the "Warning-Hold for Agricultural Inspection" notice (driver's copy) at the port-of-entry specified on the notice.

F. Violations.
1. The inspector shall place any commodities not meeting the requirements of subsections (C)(1) and (C)(2) under quarantine and notify the shipper in writing of the following options:
   a. Reship the commodity out-of-state;
   b. Provide the necessary labor and material to open the package and reseal it after inspection; or
   c. Under the supervision of an inspector, destroy the shipment.
2. Any person who violates any of the following provisions shall submit the load for complete inspection at a port-of-entry, or where apprehended;
   a. Fails to comply with requirements on the "Warning-Hold for Agricultural Inspection" notice;
   b. Fails to comply with the inspector's instructions;
   c. Breaks the seals of a sealed vehicle; or
   d. Delivers a product under quarantine before it is released by an inspector, or authorized by the Director.

Historical Note

Former Rule, Quarantine Regulation 3. Section R3-1-51 renumbered to R3-4-202 (Supp. 91-4). Section repealed by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). New Section R3-4-202 renumbered from R3-4-201 and amended by final rulemaking at 19 A.A.R. 3860, effective January 4, 2014 (Supp. 13-4).

R3-4-203. Repealed

Historical Note

Former Rule, Quarantine Regulation 4. Repealed effective October 23, 1978 (Supp. 78-5). Section R3-1-52 renumbered to R3-4-203 (Supp. 91-4).

R3-4-204. Boll Weevil and Pink Bollworm Pests: Interior Quarantine

A. Definitions. The following terms apply to this Section:
1. "Crop remnant" means the stalks, leaves, bolls, lint, pods, and seeds of cotton;
2. "Pests" means any of the following:
   a. Pink bollworm, *Pectinophora gossypiella (*Saunders); or
   b. Boll weevil complex, *Anthonomus grandis (*Boheman) complex.

B. Regulated commodities and appliances.
1. Cotton, all parts;
2. Cotton gin trash;
3. Used cotton harvesting machines; and
4. Other materials, products, and equipment that are means of disseminating or proliferating the pests.

C. Cotton gin trash. Any person operating an Arizona cotton gin shall daily destroy cotton gin trash by using a method prescribed in the Treatment Manual.

D. Restrictions.
1. A person shall not ship or transport a regulated commodity or appliance from an area infested with pests except pursuant to a limited permit issued by or a compliance agreement with the Department.
2. Any person intending to ship or transport a regulated commodity pursuant to a limited permit or compliance agreement shall provide the Department with the following information before the date of movement or shipment:
   a. The quantity of the regulated commodity or appliance to be moved;
   b. The location of the commodity or appliance;
   c. The names and addresses of the consignee and consignor;
   d. The method of shipment; and
   e. The scheduled date of the shipment.
3. The shipper shall attach all permits and compliance agreements to the manifest, waybill, or bill of lading which shall accompany the shipment.
4. Permits and compliance agreements shall specify the manner of handling or treating a regulated commodity or appliance. Pink bollworm and boll weevil treatment shall be under official supervision and applied as prescribed in the Treatment Manual.

E. Cultural practices.
1. Arizona's cultural zones are:
   a. Zone "A" -- Yuma County west of a line extended directly north and directly south of Avenue 58E.
   b. Zone "B" -- Cochise County, Graham County, and Greenlee County.
   c. Zone "C" -- Mohave County and La Paz County, except for the following: T6N, R11W, 12W, 13W; T5N, R12W, 13W; T4N, R12W, 14W, 15W; T3N, R10W, 11W; and T2N, R11W.
   d. Zone "D" -- Pima County; the following portions of Pinal County: T10S, R10E, sections 34-36; T10S, R11E, section 31; T7S, R16E; T6S, R16E; T5S, R15E; T5S, R16E and T4S, R14E; and the following portions of the Aguila area: T6N, R8W; T7N, R8W, 9W, 10W; T7N, R11W, other than sections 24, 25 and 36; and T8N, R9W, sections 31-36.
   e. Zon "E" -- All portions of the state not included in zones "A", "B", "C", and "D."
2. No stub, soca, or volunteer cotton shall be grown in or allowed to grow in the state. The landowner or grower shall be responsible for eliminating stub, soca, or volunteer cotton.
3. Tillage deadline. Except as provided in subsection (E)(4), a grower shall ensure that a crop remnant of a host plant remaining in the field after harvest is shredded and the land tilled to destroy the host plant and its root system so no stalks remain attached to the soil before the following dates or before planting another crop, whichever occurs earlier: Zone "A", January 15; Zone "B", March 1; Zone "C", February 15; Zone "D", March 1; Zone "E", February 15.
4. Rotational crop following cotton harvest.
   a. If a grower elects to plant a small-grain crop following a cotton harvest, the grower may, after the host plant is shredded, irrigate and plant with wheat, barley, or oats (or other similar small-grain crops approved in writing by the Associate Director before planting) instead of tilling as prescribed in subsection (E)(3). The small-grain crop shall be planted before the tillage deadline for the zone.
   b. The Associate Director shall approve small-grain crops other than wheat, barley, and oats, if the planting, growth, and harvest cycles of the small-grain crop prevents the maturation of stub, soca, or volunteer cotton. A grower shall submit a written request for approval of a small-grain crop, other than wheat, barley, or oats, at least 15 days before the tillage deadline for the zone. The written request shall include the scientific and common name of the proposed small-grain crop and the estimated date of harvest.
   c. If a grower elects to plant a crop other than an approved small-grain crop following a cotton harvest, the requirements specified in subsection (E)(3) apply.
5. Planting dates.
   a. A grower who meets the tillage deadline specified in subsection (E)(3) for the preceding cotton crop year shall not plant cotton earlier than 15 days after the tillage deadline for the zone.
   b. A grower who does not meet the tillage deadline specified in subsection (E)(3) for the preceding cotton crop year shall not plant cotton on a farm until 15 days after the grower ensures that all crop remnants of a host plant remaining in the fields after harvest are shredded and the land tilled to destroy the host plant and its root system so no stalks remain attached to the soil.
6. Dry planting. Any grower who meets the tillage deadline for the zone may dry plant cotton five days after the tillage deadline for that zone, but shall not water until 15 days after the tillage deadline for that zone.

7. An inspector shall give written notice to any owner or person in charge or control of the nuisance found in violation of subsection (E). The processes established in subsections (E)(3) and (E)(4) shall be repeated, as necessary, to destroy the pests.

F. Advisory Committee. The Director, as necessary, shall appoint an advisory committee composed of the nominated representatives of the Arizona Cotton Growers Association and the Arizona Cotton Research and Protection Council and such other individuals as may be necessary to make recommendations to the Department on amendments to this Section.

Historical Note

Former Rule, Quarantine Regulation 5. Amended effective January 24, 1978 (Supp. 78-1). Former Section R3-4-53 repealed, new Section R3-4-53 adopted effective December 2, 1982. See also R3-4-53.01 through R3-4-53.07 (Supp. 82-6). Section R3-1-53 renumbered to R3-4-204 (Supp. 91-4). Section repealed, new Section adopted effective May 7, 1993 (Supp. 93-2). Amended effective September 22, 1994 (Supp. 94-3). Amended effective July 10, 1995 (Supp. 95-3). Amended effective November 7, 1996 (Supp. 96-4). Amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Amended by final rulemaking at 6 A.A.R. 2082, effective May 15, 2000 (Supp. 00-2). Amended by final rulemaking at 19 A.A.R. 3860, effective January 4, 2014 (Supp. 13-4).

R3-4-205. Renumbered

Historical Note

Adopted effective December 2, 1982. See also R3-4-53 and R3-4-53.02 through R3-4-53.07 (Supp. 82-6). Section R3-1-53.01 renumbered to R3-4-205 (Supp. 91-4). Repealed effective May 7, 1993 (Supp. 93-2). New Section adopted effective December 20, 1994 (Supp. 94-4). Section R3-4-205 renumbered to R3-4-501 and amended, effective April 9, 1998 (Supp. 98-2).

R3-4-206. Repealed

Historical Note

Adopted effective December 2, 1982. See also R3-4-53, R3-4-53.01 and R3-4-53.03 through R3-4-53.07 (Supp. 82-6). Section R3-1-53.02 renumbered to R3-4-206 (Supp. 91-4). Repealed effective May 7, 1993 (Supp. 93-2).

R3-4-207. Repealed

Historical Note

Adopted effective December 2, 1982. See also R3-4-53, R3-4-53.01, R3-4-53.02 and R3-4-53.04 through R3-4-53.07 (Supp. 82-6). Section R3-1-53.03 renumbered to R3-4-207 (Supp. 91-4). Repealed effective May 7, 1993 (Supp. 93-2).

R3-4-208. Repealed

Historical Note

Adopted effective December 2, 1982. See also R3-4-53, R3-4-53.01 through R3-4-53.03 and R3-4-53.05 through R3-4-53.07 (Supp. 82-6). Section R3-1-53.04 renumbered to R3-4-208 (Supp. 91-4). Repealed effective May 7, 1993 (Supp. 93-2).

R3-4-209. Repealed

Historical Note

Adopted effective December 2, 1982. See also R3-4-53, R3-4-53.01 through R3-4-53.04, R3-4-53.06, and R3-4-53.07 (Supp. 82-6). Amended effective October 21, 1983 (Supp. 83-5). Amended effective July 24, 1985 (Supp. 85-4). Amended effective May 5, 1986 (Supp. 86-3). Amended effective May 10, 1988 (Supp. 88-2). Amended subsection (B) effective December 27, 1988 (Supp. 88-4). Amended effective December 22, 1989 (Supp. 89-4). Section R3-1-53.06 renumbered to R3-4-209 (Supp. 91-4). Repealed effective May 7, 1993 (Supp. 93-2).

R3-4-210. Repealed

Historical Note

Adopted effective December 2, 1982. See also R3-4-53, R3-4-53.01 through R3-4-53.05 and R3-4-53.07 (Supp. 82-6). Section R3-1-53.06 renumbered to R3-4-210 (Supp. 91-4). Repealed effective May 7, 1993 (Supp. 93-2).

R3-4-211. Repealed

Historical Note

Adopted effective December 2, 1982. See also R3-4-53, R3-4-53.01 through R3-4-53.06 (Supp. 82-6). Section R3-1-53.07 renumbered to R3-4-211 (Supp. 91-4). Repealed effective May 7, 1993 (Supp. 93-2).

R3-4-212. Repealed

Historical Note

Former Rule, Quarantine Regulation 6. Amended effective July 1, 1975 (Supp. 75-1). Amended effective April 26, 1976 (Supp. 76-2). Amended effective June 16, 1977 (Supp. 77-3). Repealed effective June 19, 1978 (Supp. 78-3). Adopted as an emergency effective October 21, 1983, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 83-5). Adopted as an emergency effective January 19, 1984, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 84-1). Emergency expired. Former Section R3-4-54 adopted as an emergency now adopted without change effective May 15, 1984. See also R3-4-54.01 thru R3-4-54.05 (Supp. 84-3). Section R3-1-54 renumbered to R3-4-212 (Supp. 91-4). Repealed effective April 3, 1997 (Supp. 97-2).

R3-4-213. Repealed

Historical Note

Adopted as an emergency effective October 21, 1983, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 83-5). Adopted as an emergency effective January 19, 1984, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 84-1). Emergency expired. Former Section R3-4-54.01 adopted as an emergency now adopted and amended effective May 15, 1984. See also R3-4-54, R3-4-54.02 thru R3-4-54.05 (Supp. 84-3). Section R3-1-54.01 renumbered to R3-4-213 (Supp. 91-4). Repealed effective April 3, 1997 (Supp. 97-2).

R3-4-214. Repealed

Historical Note

Adopted as an emergency effective October 21, 1983, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 83-5). Adopted as an emergency effective January 19, 1984, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 84-1). Emergency expired. Former Section R3-4-54.02 adopted as an emergency now adopted and amended effective May 15, 1984. See also R3-4-54, R3-4-54.01, R3-4-54.03 thru R3-4-54.05 (Supp. 84-3). Section R3-1-54.02 renumbered to R3-4-214 (Supp. 91-4). Repealed effective April 3, 1997 (Supp. 97-2).

R3-4-215. Repealed

Historical Note

Adopted as an emergency effective October 21, 1983, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 83-5). Adopted as an emergency effective January 19, 1984, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 84-1). Emergency expired. Former Section R3-4-54.03 adopted as an emergency now adopted and amended effective May 15, 1984. See also R3-4-54, R3-4-54.01, R3-4-54.02, R3-4-54.04 and R3-4-54.05 (Supp. 84-3). Section R3-1-54.03 renumbered to R3-4-215 (Supp. 91-4). Repealed effective April 3, 1997 (Supp. 97-2).

R3-4-216. Repealed

Historical Note

Adopted as an emergency effective October 21, 1983, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 83-5). Adopted as an emergency effective January 19, 1984, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 84-1). Emergency expired. Former Section R3-4-54.04 adopted as an emergency now adopted and amended effective May 15, 1984. See also R3-4-54, R3-4-54.01 thru R3-4-54.03, and R3-4-54.05 (Supp. 84-3). Section R3-1-54.04 renumbered to R3-4-216 (Supp. 91-4). Repealed effective April 3, 1997 (Supp. 97-2)

R3-4-217. Repealed

Historical Note

Adopted effective May 15, 1984. See also R3-4-54, R3-4-54.01 thru R3-4-54.04 (Supp. 84-3). Section R3-1-54.05 renumbered to R3-4-217 (Supp. 91-4). Repealed effective April 3, 1997 (Supp. 97-2).

R3-4-218. Boll Weevil and Pink Bollworm Pests: Exterior Quarantine

A. Definitions
1. "Cotton appliance" means a container used in handling cotton, including sacks, bags, tarps, boxes, crates, and machinery used in planting, harvesting and transporting cotton.
2. "Cottonseed" means a seed derived from cotton plants which is destined for propagation or other use.
3. "Fumigation certificate" means a quarantine compliance certificate that specifies the fumigation chemical used, the treatment schedule, and the commodity treated.
4. "Hibiscus" means all parts of *Hibiscus* spp.
5. "Pest" means any of the following:
   a. Boll weevil, *Anthonomus grandis* (Boheman); or
   b. Pink bollworm, *Pectinophora gossypiella* (Saunders).
6. "Spanish moss" means all parts of *Tillandsia usneoides*.

B. Area under quarantine.
1. Boll weevil. In the state of Texas, the following counties: Anderson, Angelina, Aransas, Atascosa, Austin, Bastrop, Bee, Bell, Bexar, Blanco, Bosque, Bowie, Brazoria, Brazos, Brooks, Burleson, Burnett, Caldwell, Calhoun, Cameron, Camp, Cass, Chambers, Cherokee, Collin, Colorado, Comal, Cooke, Coryell, Dallas, Delta, Denton, De Witt, Dimmit, Duval, Ellis, Falls, Fannin, Fayette, Fort Bend, Franklin, Freestone, Frio, Galveston, Gillespie, Goliad, Gonzales, Grayson, Gregg, Grimes, Guadalupe, Hamilton, Hardin, Harris, Harrison, Hays, Henderson, Hidalgo, Hill, Hood, Hopkins, Houston, Hunt, Jack, Jackson, Jasper, Jefferson, Jim Hogg, Jim Wells, Johnson, Karnes, Kaufman, Kendall, Kenedy, Kinney, Kleberg, Lamar, Lampasas, La Salle, Lavaca, Lee, Leon, Liberty, Limestone, Live Oak, Llano, Madison, Marion, Matagorda, Maverick, McLennan, McMullen, Medina, Milam, Mills, Montague, Montgomery, Morris, Nacogdoches, Navarro, Newton, Nueces, Orange, Panola, Parker, Polk, Rains, Red River, Refugio, Robertson, Rockwall, Rusk, Sabine, San Augustine, San Jacinto, San Patricio, San Saba, Shelby, Smith, Somervell, Starr, Tarrant, Titus, Travis, Trinity, Tyler, Upshur, Uvalde, Van Zandt, Victoria, Walker, Waller, Washington, Webb, Wharton, Willacy, Williamson, Wilson, Wise, Wood, Zapata, and Zavala.
2. Pink bollworm. New Mexico, Texas, and the following counties of California: Fresno, Imperial, Inyo, Kern, Kings, Los Angeles, Madera, Merced, Orange, Riverside, San Bernardino, San Benito, San Diego, and Tulare.

C. Regulated commodities and appliances.
1. Gin trash,
2. Cotton lint,
3. Cottonseed,
4. Used cotton appliances that have any cotton plants attached or contained therein,
5. Cotton plants,
6. Spanish moss, and
7. Hibiscus plants.

D. Restrictions. A person shall not ship or transport into Arizona from an area under quarantine:
1. For the pink bollworm, any regulated commodity or appliance that is not accompanied by a permit or certificate required by 7 CFR 301.52 et seq., revised January 1, 2013. This incorporation by reference does not include any later amendments or editions and is available from the Department and online at http://www.gpo.gov/fdsys/.
2. For the boll weevil,
   a. Gin trash, cotton lint, cottonseed, or used cotton appliances that have any cotton plants attached or contained therein unless the commodity or appliance is accompanied by an original fumigation certificate attesting the commodity or appliance has been fumigated as prescribed in the Treatment Manual.
   b. Cotton plants or hibiscus plants unless the commodity is accompanied by an original quarantine compliance certificate attesting the commodity was treated with a chemical to kill the pest and was visually inspected and found free of all live life stages of the pest within five days of shipment.
   c. Spanish moss, unless the commodity is accompanied by an original quarantine compliance certificate attesting the commodity was treated by one of the following methods:
      i. Commercial drying; or
      ii. Chemical treatment using a pesticide registered and labeled for use on the commodity to kill all live life stages of the pest.

Historical Note

Former Rule, Quarantine Regulation 7. Section R3-4-55 repealed, new Section adopted effective August 16, 1990 (Supp. 90-3). Section R3-1-55 renumbered to R3-4-218 (Supp. 91-4). Appendix to R3-4-218 removed; R3-4-218 amended by final rulemaking effective January 4, 2014 (Supp. 13-4).

R3-4-219. Citrus Fruit Surface Pest

A. Definitions.

"Pest" means all life stages of the following:

Aonidiella aurantii, California red scale;

Aonidiella citrina, Yellow scale;

Asynonychus godmani, Fuller rose beetle;
Chrysomphalus aonidum, Florida red scale;
Cornuaspis beckii, Purple scale;
Lepidosaphes gloverii, Glover scale;
Maconellicoccus hirsutus, Pink hibiscus mealybug;
Parlatoria pergandii, Chaff scale;
Phyllocoptruta oleivora, Citrus rust mite; or
Pseudococcus comstocki, Comstock mealybug.

B. Area under quarantine. All states, territories, and districts of the United States, except the state of Arizona.

C. Regulated commodities and appliances.
1. Commodities. The fresh fruit of all species, varieties, and hybrids of the genera *Citrus*, *Fortunella*, and *Poncirus*.
2. Appliances. An appliance used in a citrus grove, citrus nursery, or other area to pick, pack, or handle a regulated commodity listed in subsection (C)(1).

D. Restrictions.
1. A person who ships into Arizona a regulated commodity or appliance listed in subsection (C) shall ensure that the commodity or appliance is free of stems, leaves, and plant parts.
2. A person shall not ship into Arizona a regulated commodity or appliance from an area under quarantine unless each shipment is accompanied by an original certificate issued by a plant regulatory official of the state of origin attesting that the regulated commodity or appliance was treated by a method listed in subsection (F), under the official's supervision.

E. Exemption. The Director shall issue a permit to allow a regulated commodity from an area under quarantine to enter Arizona without treatment as prescribed in subsection (F) if the applicant complies with all conditions of the permit and the regulated commodity:
1. Originates from an area that a plant regulatory official of the state of origin certifies as pest-free; or
2. Is shipped to an Arizona juicing facility located outside of Yuma County; or
3. Is commercially packaged and is shipped to an Arizona business that will redistribute the regulated commodity out-of-state.

F. Treatment.
1. Hydrogen cyanide fumigation. The regulated commodity shall be treated for one hour at the following rate:

Pulp Temperature	Rate per 100 cu. ft.
60° F to 85° F	25 cc HCN gas

2. Methyl bromide fumigation (Q label). The regulated commodity shall be treated for two hours at one of the following rates:

Pulp Temperature	Rate per 1000 cu. ft.
60° F to 79° F	3 lbs.
80° F or higher	2 1/2 lbs.

3. Irradiation. The regulated commodity shall be treated at a rate approved by the Director.
4. Steam treatment. The regulated appliance shall be cleaned to remove all fruit, leaves, stems, and other debris and then steam-treated.
5. Other treatment. The regulated commodity or appliance shall be treated by any other method approved by the Director.

G. Disposition of regulated commodity or appliance not in compliance. A regulated commodity or appliance shipped into Arizona in violation of this Section shall be destroyed, treated, or transported out of state as prescribed at A.R.S. Title 3, Chapter 2, Article 1.

Historical Note

Former Rule, Quarantine Regulation 8. Repealed effective December 19, 1980 (Supp. 80-6). Adopted as an emergency effective April 11, 1984, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 84-2). Emergency adoption expired. Permanent rule adopted effective November 15, 1984 (Supp. 84-6). Former Section R3-4-56 repealed, former Sections R3-4-56.01 through R3-4-56.04 renumbered and amended as Section R3-4-56 effective June 20, 1986 (Supp. 86-3). Repealed June 29, 1990 (Supp. 90-2). New Section adopted effective April 11, 1991 (Supp. 91-2). Section R3-1-56 renumbered to R3-4-219 (Supp. 91-4). Amended by final rulemaking at 10 A.A.R. 3380, effective October 2, 2004 (Supp. 04-3).

R3-4-220. Citrus Nursery Stock Pests

A. Definitions. "Pest" means any of the following viral diseases or arthropods:
1. Viral diseases:
Cachexia (CVd-II),
Citrus Exocortis Virus (CEVd),
Citrus Psorosis Virus (CPsV), or
Citrus Tristeza Virus (CTV).
2. Arthropods. All life stages of:
Aceria sheldoni, Citrus bud mite;
Maconellicoccus hirsutus, Pink hibiscus mealybug;
Phyllocoptruta oleivora, Citrus rust mite; or
Pseudococcus comstocki, Comstock mealybug.

B. Area under quarantine. All states, territories, and districts of the United States, except the state of Arizona.

C. Regulated commodities and appliances.
1. Commodities. A plant or plant part, except seed or attached green fruit, of all species, varieties, or hybrids of the genera *Citrus*, *Eremocitrus*, *Fortunella*, *Poncirus*, and *Microcitrus*.
2. Appliances. An appliance used in a citrus grove, citrus nursery, or other area to handle citrus nursery stock listed in subsection (C)(1).

D. Restrictions.
1. A person may ship a regulated commodity into Arizona from an area under quarantine if the regulated commodity is accompanied by a certificate issued by a plant regulatory official from the origin state, attesting that the commodity:
   a. Originates from an area not under quarantine for citrus tristeza virus, and
   b. Originates from a source tree that is:
      i. Tested for Cachexia, citrus exocortis virus, and citrus psorosis virus; or
      ii. From budwood tested for Cachexia, citrus exocortis virus, and citrus psorosis virus; and
      iii. Tested annually for citrus tristeza virus; and
   c. Was treated within five days before shipment with a chemical to kill the arthropod pests listed in subsection (A)(2), and that the commodity is free of all live life stages of the arthropod pests listed in subsection (A)(2).
2. A person shall not ship a Meyer lemon plant or plant part, except fruit, into Arizona. An exception is allowed for the selection Improved Meyer lemon plant or plant part, which may be shipped into Arizona in compliance with this Section.
3. A person shipping a regulated commodity into Arizona shall attach a single tag or label to each plant or plant

part, or to each individual container containing a plant or plant part, that is intended for resale by an Arizona receiver. The tag or label shall contain the following information separately provided for each scion variety grafted to a single rootstock:
   a. Name and address of the nursery that propagated the plant,
   b. Scion variety name,
   c. Scion variety registration number, and
   d. Rootstock variety name.
4. A person shipping a regulated commodity into Arizona shall ensure the commodity complies with the entry requirements prescribed in R3-4-226 and R3-4-238.
5. A person may ship a regulated appliance into Arizona if the appliance is accompanied by a certificate issued by a plant regulatory official from the origin state. The certificate shall state that the appliance was treated within five days before shipment with a chemical to kill the arthropod pests listed in subsection (A)(2), and that the appliance is free of all live life stages of the arthropod pests listed in subsection (A)(2).

E. Disposition of regulated commodity or appliance not in compliance. A regulated commodity or appliance shipped into Arizona in violation of this Section shall be destroyed, treated, or transported out-of-state as prescribed at A.R.S. Title 3, Chapter 2, Article 1.

Historical Note

Former Rule, Quarantine Regulation 9. Amended effective July 1, 1975 (Supp. 75-1). Former Section R3-4-57 amended and renumbered as R3-4-57 through R3-4-57.05 effective February 16, 1982 (Supp. 82-1). Section repealed, new Section adopted effective June 14, 1990 (Supp. 90-2). Section R3-1-57 renumbered to R3-4-220 (Supp. 91-4). Amended by final rulemaking at 10 A.A.R. 3380, effective October 2, 2004 (Supp. 04-3). Amended by final rulemaking at 12 A.A.R. 4065, effective December 4, 2006 (Supp. 06-4).

R3-4-221. Repealed

Historical Note

Former Section R3-4-57 amended and renumbered as R3-4-57 through R3-4-57.05 effective February 16, 1982 (Supp. 82-1). Repealed effective June 14, 1990 (Supp. 90-2). Section R3-1-57.01 renumbered to R3-4-221 (Supp. 91-4).

R3-4-222. Repealed

Historical Note

Former Section R3-4-57 amended and renumbered as R3-4-57 through R3-4-57.05 effective February 16, 1982 (Supp. 82-1). Repealed effective June 14, 1990 (Supp. 90-2). Section R3-1-57.02 renumbered to R3-4-222 (Supp. 91-4).

R3-4-223. Repealed

Historical Note

Former Section R3-4-57 amended and renumbered as R3-4-57 through R3-4-57.05 effective February 16, 1982 (Supp. 82-1). Repealed effective June 14, 1990 (Supp. 90-2). Section R3-1-57.03 renumbered to R3-4-223 (Supp. 91-4).

R3-4-224. Repealed

Historical Note

Former Section R3-4-57 amended and renumbered as R3-4-57 through R3-4-57.05 effective February 16, 1982 (Supp. 82-1). Repealed effective June 14, 1990 (Supp. 90-2). Section R3-1-57.04 renumbered to R3-4-224 (Supp. 91-4).

R3-4-225. Repealed

Historical Note

Former Section R3-4-57 amended and renumbered as R3-4-57 through R3-4-57.05 effective February 16, 1982 (Supp. 82-1). Repealed effective June 14, 1990 (Supp. 90-2). Section R3-1-57.05 renumbered to R3-4-225 (Supp. 91-4).

R3-4-226. Scale Insect Pests

A. Definitions.
"Pest" means all life stages of the following:
Aonidiella aurantii, California red scale;
Aonidiella citrine, Yellow scale;
Chrysomphalus aonidum, Florida red scale; or
Pulvinaria psidi, Green shield scale.

B. Area under quarantine. The entire states of Alabama, Arkansas, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, and Texas, and the Commonwealth of Puerto Rico.

C. Regulated commodities. Plants and all plant parts, except seed, of the genera listed below:
Camellia,
Chrysalidocarpus,
Citrus,
Cycas,
Dracaena,
Eremocitrus,
Euonymus,
Ficus,
Fortunella,
Ilex,
Ligustrum,
Microcitrus,
Poncirus, and
Rosa

D. Restrictions. A person may ship a regulated commodity to Arizona from an area under quarantine if each shipment is accompanied by a certificate issued by a plant regulatory official of the origin state within five days before shipment attesting that one of the following is true:
1. A regulated commodity of the genera *Citrus*, *Eremocitrus*, *Fortunella*, *Microcitrus*, and *Poncirus* was treated with a chemical to kill the pests listed in subsection (A) and was visually inspected and found free of all live life stages of the pests listed in subsection (A);
2. A regulated commodity not listed in subsection (D)(1):
   a. Was treated with a chemical to kill the pests listed in subsection (A) and was visually inspected and found free of all live life stages of the pests listed in subsection (A); or
   b. Originated from a nursery with a pest management program recognized and monitored by the origin state to control the pests listed in subsection (A), and was visually inspected and found free of all live life stages of the pests listed in subsection (A).

E. Disposition of regulated commodity not in compliance. A regulated commodity shipped into Arizona in violation of this Section shall be destroyed, treated, or transported out-of-state as prescribed at A.R.S. Title 3, Chapter 2, Article 1.

Historical Note

Former Rule, Quarantine Regulation 10; Amended effective August 31, 1981 (Supp. 81-4). Former Section R3-4-58 repealed, new Section R3-4-58 adopted effective July

13, 1989 (Supp. 89-3). Section R3-1-58 renumbered to R3-4-226 (Supp. 91-4). Amended by final rulemaking at 10 A.A.R. 3380, effective October 2, 2004 (Supp. 04-3). Amended by final rulemaking at 12 A.A.R. 4065, effective December 4, 2006 (Supp. 06-4).

R3-4-227. Repealed

Historical Note

Former Rule, Quarantine Regulation 11. Section R3-1-59 renumbered to R3-4-227 (Supp. 91-4). Repealed effective April 3, 1997 (Supp. 97-2).

R3-4-228. European Corn Borer

A. Definitions. The following terms apply in this Section:

"Corn" means *Zea* spp.

"Fragment" means a portion of a regulated commodity that cannot pass through a 1/2" aperture or a completely whole, round, and uncrushed piece of cob, stalk, or stem of at least 1" in length and 3/16" in diameter.

"Pest" means all life stages of the European corn borer, *Ostrinia nubilalis*.

"Shelled grain" means the seed or kernel of corn or sorghum that has been separated from every other plant part.

"Sorghum" means *Sorghum* spp.

B. Area under quarantine.
1. The entire states of Alabama, Arkansas, Colorado, Connecticut, Delaware, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming.
2. The District of Columbia.
3. In the state of Florida, the following counties: Calhoun, Escambia, Gadsden, Hamilton, Holmes, Jackson, Jefferson, Madison, Okaloosa, and Santa Rosa.
4. In the state of Louisiana, the following parishes: Bossier, Caddo, Concordia, East Carroll, Franklin, Madison, Morehouse, Natchitoches, Ouachita, Red River, Richland, Tensas, and West Carroll.
5. In the state of New Mexico, the following counties: Chaves, Curry, Quay, Roosevelt, San Juan, Santa Fe, Torrance, Union, and Valencia.
6. In the state of Texas, the following counties: Bailey, Carson, Castro, Dallam, Deaf Smith, Floyd, Gray, Hale, Hansford, Hartley, Hutchinson, Lamb, Lipscomb, Moore, Ochiltree, Oldham, Parmer, Potter, Randall, Roberts, Sherman, and Swisher.

C. Regulated commodities. The plants corn and sorghum and every plant part, including seed, shelled grain, stalks, ears, cobs, fragments, and debris are regulated commodities under this Section.

D. Restrictions. A person shall not ship into Arizona a regulated commodity from an area under quarantine unless each shipment is accompanied by an original certificate, issued by a plant regulatory official of the state of origin, attesting that the regulated commodity was treated by a method listed in subsection (F), under the official's supervision.

E. Exemptions.
1. Treatment prescribed in subsection (F) is waived for all of the following:
   a. Shelled grain, if the grain is accompanied by an original certificate issued by a plant regulatory official of the state of origin attesting that:
      i. The shelled grain was passed through a 1/2" or smaller-size mesh screen at the place of origin, and
      ii. The shipment is free of plant fragments capable of harboring the larval life stage of the pest;
   b. Commercially packaged shelled popcorn, planting seed, and grain for human consumption; or
   c. A regulated commodity manufactured or processed by a method that eliminates the pest.
2. The Director shall issue a permit to allow a regulated commodity from an area under quarantine, other than one exempt under subsection (E)(1), to enter Arizona without the treatment prescribed in subsection (F) if the regulated commodity originates from an area certified as pest free by a plant regulatory official of the state of origin.

F. Treatment.
1. Methyl bromide fumigation (Q label) applied at label rates.
2. Any other treatment approved by the Director.

G. Disposition. If a person ships a regulated commodity into Arizona in violation of this Section, the regulated commodity shall be destroyed, treated, or transported out-of-state as prescribed in A.R.S. Title 3, Chapter 2, Article 1.

Historical Note

Former Rule, Quarantine Regulation 12. Amended effective July 1, 1975 (Supp. 75-1). Amended effective June 19, 1978 (Supp. 78-3). Amended subsection (C) effective January 21, 1981 (Supp. 81-1). Amended effective August 11, 1987 (Supp. 87-3). Section R3-1-60 renumbered to R3-4-228 (Supp. 91-4). Amended by final rulemaking at 10 A.A.R. 3374, effective October 2, 2004 (Supp. 04-3).

R3-4-229. Nut Tree Pests

A. In addition to the definitions provided in A.R.S. § 3-201 and R3-4-102, the following terms apply to this Section:
1. "Brooming" means a virus-like disease that drastically reduces nut production and sometimes causes death of the host tree.
2. "Pest" means any of the following:
   a. Pecan leaf casebearer, *Acrobasis juglandis* (LeBaron);
   b. Pecan nut casebearer, *Acrobasis nuxvorella* (Neunzig);
   c. Pecan phylloxera, *Phylloxera devastatrix*;
   d. The pathogen that causes brooming disease of walnut.

B. Area under quarantine: All states, districts, and territories of the United States except California.

C. Infested area.
1. For *Arcobasis* spp.: All states and districts east of and including the states of Montana, Wyoming, Colorado, Oklahoma, and Texas; in New Mexico, the counties of Chaves, Lea, Roosevelt, Eddy, Dona Ana, Otero, and Quay.
2. For pecan phylloxera: Alabama, Arkansas, Louisiana, Mississippi, Oklahoma, and Texas.
3. For brooming disease of walnut: All states and districts east of and including Montana, Wyoming, Colorado, and New Mexico.

D. Commodities covered:

1. All species and varieties of the following trees and all plant parts capable of propagation, except the nuts. Plant parts include buds, scions, and rootstocks:
   a. Hickory and pecan (*Carya* spp.);
   b. Walnut and butternut (*Juglans* spp.);
2. Pecan firewood;
3. Any used appliance, used box, or sack used during the growing, harvesting, handling, transporting, or storing nuts and hulls.

E. Restrictions:
1. The commodities listed in subsection (D)(1) shall be admitted into Arizona:
   a. From the infested area prescribed in subsections (C)(1) and (C)(2) if treated at origin and each lot or shipment is accompanied by a certificate issued by the origin state department of agriculture affirming the commodity has been treated in accordance with subsection (F);
   b. From an area under quarantine outside the infested area, if each lot or shipment is accompanied by a certificate issued by the origin state department of agriculture affirming that the commodities originated in a county not known to be infested with the pests listed in subsections (A)(2)(a), (b), and (c).
2. The commodities listed in subsection (D)(1)(b) shall be:
   a. Prohibited from entering Arizona from the infested area prescribed in subsection (C)(3);
   b. Admitted into Arizona from an area under quarantine outside the infested area prescribed in subsection (C)(3), if each lot or shipment is accompanied by a certificate issued by the origin state department of agriculture affirming brooming is unknown in the origin county.
3. The commodities listed in subsections (D)(2) and (D)(3) are prohibited from entering the state unless fumigated as prescribed in subsection (F)(1).

F. Treatments:
1. Methyl bromide fumigation at normal atmospheric pressure, with circulations maintained for 30 minutes, as follows:
   a. 2 lbs. per 1,000 cu.ft. for four hours at 70° F or more,
   b. 3 lbs. per 1,000 cu.ft. for four hours at 60-69° F.
2. A hot-water dip at 140° F or more for a minimum of 30 continuous seconds.
3. Appliances.
   a. Steam-cleaned, inspected, and certified free from debris by the origin state, or
   b. Cold treatment in a cold storage chamber at or below 0° F for at least seven consecutive days (168 hours).
4. Any other treatment approved by the Associate Director.

Historical Note

Former Rule, Quarantine Regulation 13. Amended subsections (C), (E) and (G) effective May 5, 1986 (Supp. 86-3). Section R3-1-61 renumbered to R3-4-229 (Supp. 91-4). Amended effective January 16, 1996 (Supp. 96-1). Amended by final rulemaking at 6 A.A.R. 41, effective December 8, 1999 (Supp. 99-4). Subsection citation in subsection (E)(1)(b) amended to correct manifest typographical error (Supp. 03-2).

R3-4-230. Repealed

Historical Note

Former Rule, Quarantine Regulation 14. Section R3-1-62 renumbered to R3-4-230 (Supp. 91-4). Section repealed by final rulemaking at 10 A.A.R. 3380, effective October 2, 2004 (Supp. 04-3).

R3-4-231. Nut Pests

A. Definition. In addition to the definitions provided in A.R.S. § 3-201 and R3-4-102, the following term applies to this Section:
"Pest" means any of the following:
1. Pecan weevil, C*urculio caryae* (Horn);
2. Butternut curculio, *Conotrachelus juglandis LeC*;
3. Black walnut curculio, *Conotrachelus retentus Say*;
4. Hickory shuckworm, *Laspeyresia caryana (Fitch).*

B. Area under quarantine:
1. Pecan weevil: All states and districts of the United States except California and New Mexico.
2. Hickory shuckworm: The New Mexico counties of Lea, Eddy, and Dona Ana, and all other states and districts of the United States except California.
3. Black walnut curculio and butternut curculio: All states and districts of the United States except California.

C. Commodities covered:
1. Nuts of all species and varieties of hickory, pecan *(Carya spp.),* walnut and butternut *(Juglans spp.),* except extracted nut meats.
2. Any used appliance, used box or sack used during growing, harvesting, handling, transporting, or storing nuts and hulls.

D. Restrictions:
1. A commodity listed in subsection (C)(1), originating in or shipped from the area under quarantine, shall be admitted into Arizona if the commodity has been cleaned of husks, hulls, debris, and sticktights and each lot or shipment is accompanied by a certificate issued by the origin state department of agriculture affirming the commodity has been treated in accordance with subsection (E).
2. A commodity listed in subsection (C)(2) shall be admitted into Arizona if the commodity has been fumigated as prescribed in subsections (E)(3) and (E)(4).

E. Treatment:
1. Cold treatment: The commodities shall be held in a cold storage chamber at or below 0° F for at least seven consecutive days (168 hours). The treatment shall not start until the entire content of the lot of nuts has reached 0° F
2. A hot-water bath treatment at 140° F for a minimum of five continuous minutes. Water temperature shall be maintained at or above 140° F during the entire treatment period.
3. Methyl bromide fumigation at normal atmospheric pressure, with circulations maintained for 30 continuous minutes, as follows:
   a. 2 lbs. per 1,000 cu. ft. for four hours at least 70° F, or
   b. 3 lbs. per 1,000 cu. ft. for four hours at 60-69° F.
4. Appliances.
   a. Steam-cleaned, inspected, and certified free from debris by the origin state,
   b. Cold treatment in a cold storage chamber at or below 0° F for at least seven consecutive days (168 hours).

Historical Note

Former Rule, Quarantine Regulation 15. Amended effective July 13, 1989 (Supp. 89-3). Section R3-1-63 renumbered to R3-4-231 (Supp. 91-4). Amended by final rulemaking at 6 A.A.R. 41, effective December 8, 1999 (Supp. 99-4).

R3-4-232. Repealed

Historical Note

Former Rule, Quarantine Regulation 16. Repealed effective February 16, 1979 (Supp. 79-1). Section R3-1-64 renumbered to R3-4-232 (Supp. 91-4).

R3-4-233. Lettuce Mosaic Virus

A. Definitions. In addition to the definitions provided in R3-4-101, the following terms apply to this Section:
1. "Breeder seed" means unindexed lettuce seed that a lettuce breeder or researcher controls, and that is not available for commercial sale or propagation.
2. "Breeder trial" means breeder seed grown to develop a new variety of lettuce.
3. "Mosaic-indexed" means that a laboratory tested at least 30,000 lettuce seeds from a seed lot and found that all sampled seeds were determined to be free from lettuce mosaic virus.
4. "Pest" means lettuce mosaic virus.
5. "Unindexed lettuce seed" means lettuce seed that is not mosaic-indexed.

B. Area Under Quarantine: All states, districts, and territories of the United States.

C. Regulated Commodities: Plants and plant parts, including seeds, of all varieties of lettuce, *Lactuca sativa*.

D. Restrictions.
1. A person shall not import into, transport within, plant, or sell in Arizona unindexed lettuce seed unless the unindexed lettuce seed is exempted under subsection (E) or the person obtains a permit as prescribed in subsection (G).
2. Each container or subcontainer of mosaic-indexed seed shall bear a label with the statement "Zero infected seeds per 30,000 tested (0 in 30,000)" as well as the name of the certified or accredited laboratory that tested the seed under subsection (D)(5).
3. A person shall not import into, transport within, plant, or sell in Arizona lettuce transplants unless the transplants are exempted under subsection (E), or unless an original certificate, issued by the origin state, accompanies the shipment. The certificate shall declare:
   a. The name of the exporter,
   b. The variety name and lot number of the seed from which the transplants were grown, and
   c. Verification that the seeds from which the transplants were grown were mosaic-indexed.
4. A grower shall disk or otherwise destroy all lettuce fields within 10 days after the last day of commercial harvest or abandonment, unless prevented by documented weather conditions or circumstances beyond the control of the grower.
5. Laboratories that index lettuce seed that is shipped to Arizona shall be certified by the agricultural department of the laboratory's state of origin or by the Arizona Department of Agriculture, in accordance with A.R.S. § 3-145, or shall be accredited by the National Seed Health System. Laboratories shall provide a copy of their certificate or accreditation letter to the Arizona Department of Agriculture by January 1 of the year that shipping will take place.

E. Exemptions. The requirements of subsection (D) do not apply to:
1. Lettuce seed sold in retail packages of 1 oz. or less to the homeowner for noncommercial planting,
2. Shipments of lettuce transplants consisting of five flats or less per receiver for noncommercial planting,
3. Breeder trials for a plot of 1/20 of an acre or less, or
4. Breeder trials for a plot of greater than 1/20 of an acre but no more than 1.25 acres provided the breeder or researcher:
   a. Places a flag, marked with a trial identification number, at each corner of a breeder trial plot;
   b. Provides the following written information to the Department within 10 business days of planting breeder seed:
      i. GPS coordinates for each breeder trial plot using NAD 83 decimal degrees;
      ii. A detailed map showing the location of each breeder trial plot;
      iii. An identification number for each breeder trial plot; and
      iv. The name, address, telephone number, and e-mail address for the breeder or researcher;
   c. Monitors the lettuce for pest symptoms, and notifies the Department, by telephone, by the end of the first business day following the detection of pest symptoms;
   d. Removes and destroys all plants exhibiting pest symptoms from the breeder trial plot and places them in a sealed container for disposal in a landfill;
   e. Labels bills of lading or invoices accompanying breeder seed into Arizona with the statement "LETTUCE SEED FOR BREEDER TRIALS ONLY"; and
   f. Destroys lettuce plants remaining in a breeder trial plot within 10 days after the completion of breeding trials unless prevented by documented weather conditions or circumstances beyond the control of the researcher or breeder.

F. A breeder or researcher may conduct multiple breeder trials in Arizona under the provisions of subsection (E)(3) and (4).

G. Permits.
1. A person may apply for a permit to import unindexed lettuce seed for temporary storage in Arizona if the person:
   a. Maintains the identity of the seed while in Arizona;
   b. Does not sell or distribute the seed for use in the state;
   c. Does not transfer the seed to any other facility in the state; and
   d. Reships the seed from the state within seven days or the period of time specified on the permit, whichever is longer.
2. A person may apply for a permit to transport unindexed lettuce seed into Arizona to be mosaic-indexed.

H. Disposition of Violation.
1. Any infected shipment of lettuce seed or transplants arriving in or found within the state, in violation of this Section, shall be immediately destroyed. The owner or the owner's agent shall bear the cost of the destruction.
2. Any shipment of unindexed lettuce seed or transplants arriving in or found within the state in violation of this Section shall be immediately sent out-of-state or destroyed at the option of the owner or the owner's agent. The owner or the owner's agent shall bear the cost of the destruction or of sending the lettuce seed or transplants out-of-state.
3. Any Arizona lettuce fields in violation of this Section shall be abated as established in A.R.S. §§ 3-204 and 3-205. The owner or person in charge may be assessed a civil penalty established in A.R.S. § 3-215.01.

4. Violation of any provision of a permit issued under subsection (G) may result in suspension or revocation of the permit.

Historical Note

Former Rule, Quarantine Regulation 17. Amended effective July 1, 1975 (Supp. 75-1). Section R3-1-65 renumbered to R3-4-233 (Supp. 91-4). Section repealed; new Section adopted effective December 2, 1998 (Supp. 98-4). Amended effective December 2, 1998 (Supp. 98-4). Amended by final rulemaking at 14 A.A.R. 4091, effective December 6, 2008 (Supp. 08-4).

R3-4-234. Nematode Pests

A. Definition.
"Pest" means the reniform nematode, *Rotylenchulus reniformis*, and the burrowing nematode, *Radopholus similis* (Cobb).

B. Areas under quarantine.
1. Reniform nematode.
   a. The entire states of Florida and Hawaii.
   b. The Commonwealth of Puerto Rico.
   c. In the state of Alabama, the counties of, Autauga, Baldwin, Barbour, Bibb, Blount, Bullock, Butler, Chambers, Cherokee, Chilton, Choctaw, Clarke, Clay, Cleburne, Coffee, Colbert, Conecuh, Coosa, Dale, Dallas, DeKalb, Elmore, Escambia, Etowah, Fayette, Franklin, Geneva, Houston, Jackson, Jefferson, Lamar, Lauderdale, Lawrence, Lee, Limestone, Lowndes, Macon, Madison, Marengo, Marion, Marshall, Montgomery, Morgan, Perry, Pickens, Pike, Randolph, Saint Clair, Shelby, Sumter, Talladega, Tallapoosa, Tuscaloosa, Walker, Washington, Wilcox, and Winston.
   d. In the state of Arkansas, the counties of Ashley, Jefferson, Lonoke, and Monroe.
   e. In the state of Georgia, the counties of, Baker, Banks, Barrow, Bartow, Ben Hill, Berrien, Bleckeley, Brooks, Bulloch, Burke, Calhoun, Candler, Catoosa, Charlton, Clarke, Clay, Coffee, Colquitt, Cook, Crisp, Decatur, Dodge, Dooly, Dougherty, Early, Echols, Elbert, Emanuel, Franklin, Gordon, Grady, Hall, Hart, Houston, Jeff Davis, Jefferson, Jenkins, Johnson, Laurens, Lee, Macon, Marion, Miller, Mitchell, Montgomery, Morgan, Newton, Oconee, Peach, Pierce, Pulaski, Randolph, Richmond, Schley, Screven, Seminole, Stewart, Sumter, Tattnall, Taylor, Terrell, Thomas, Tift, Tombs, Turner, Twiggs, Walker, Walton, Warren, Washington, Wayne, Webster, Wheeler, Wilcox, and Worth.
   f. In the state of Louisiana, the parishes of, Acadia, Ascension, Assumption, Avoyelles, Beauregard, Bossier, Caddo, Calcasieu, Caldwell, Catahoula, Concordia, East Baton Rouge, East Carroll, East Feliciana, Evangeline, Franklin, Grant, Iberia, Iberville, Jefferson, Lafayette, Lafourche, Madison, Morehouse, Natchitoches, Orleans, Ouachita, Plaquemines, Pointe Coupee, Rapides, Red River, Richland, Sabine, Saint Bernard, Saint Charles, Saint Helena, Saint John the Baptist, Saint Landry, Saint Tammany, Tangipahoa, Tensas, Terrebonne, West Baton Rouge, West Carroll, and Winn.
   g. In the state of Mississippi, the counties of, Adams, Alcorn, Attala, Benton, Bolivar, Calhoun, Carroll, Chickasaw, Coahoma, Copiah, Covington, DeSoto, Forrest, George, Greene, Grenada, Hancock, Harrison, Hinds, Holmes, Humphreys, Issaquena, Itawamba, Jackson, Jones, Lafayette, Lee, Leflore, Lowndes, Madison, Marion, Marshall, Monroe, Noxubee, Oktibbeha, Panola, Perry, Pontotoc, Prentiss, Quitman, Rankin, Scott, Sharkey, Sunflower, Tallahatchie, Tippah, Tunica, Union, Warren, Washington, Yalobusha, and Yazoo.
   h. In the state of North Carolina, the counties of, Cumberland, Harnett, Hoke, Johnston, Richmond, Robeson, Sampson, and Scotland.
   i. In the state of South Carolina, the counties of, Calhoun, Clarendon, Darlington, Dillon, Florence, Kershaw, Lee, Marlboro, Orangeburg, Sumter, and Williamsburg.
   j. In the state of Texas, the counties of, Brazos, Burleson, Cameron, Fort Bend, Hidalgo, Lynn, Robertson, Starr, Terry, Wharton, and Willacy.
2. Burrowing nematode.
   a. The entire states of Florida and Hawaii.
   b. In the state of Texas, the counties of, Cameron and Hildago.
   c. The Commonwealth of Puerto Rico.

C. Regulated Commodities.
1. Soil;
2. All plants with roots, including bulbs, corms, tubers, rhizomes, and stolons; and
3. All plant cuttings for propagation.

D. Exceptions to regulated commodities.
1. Industrial sand and clay;
2. Orchids and plants produced epiphytically, if growing exclusively in or on soil-free material such as osmunda fiber, tree fern trunk, or bark;
3. Aquatic plants, including species normally growing in, on, or under water;
4. Dormant bulbs, corms, tubers, rhizomes, and stolons for propagation, if free from roots and soil; and
5. All fleshy roots, corms, tubers, and rhizomes for edible or medicinal purposes, if free of soil.

E. Quarantine Restrictions.
1. The Associate Director shall deny entry of a regulated commodity from an area under quarantine, whether moved directly from the area or by diversion or reconsignment, unless the regulated commodity is accompanied by an original certificate from the state of origin. The certificate shall state that the regulated commodity contained in the shipment is pest-free by one of the following methods:
   a. The origin state determined through an annual survey conducted within the 12-month period immediately before shipment, that the pests do not exist on the property or in the facility used to grow the regulated commodity.
   b. The regulated commodity in the shipment was sampled two weeks before shipment, and found pest-free.
   c. The regulated commodity was protected from infestation of the pests by implementing all of the following steps:
      i. Propagated from clean seed or from cuttings taken 12 inches or higher above ground level,
      ii. Planted in sterilized soil or other material prepared or treated to ensure freedom from the pests,
      iii. Retained in a sterilized container or bed,
      iv. Placed on a sterilized bench or sterilized support 18 inches or higher from the ground or floor level, and

v. Found pest-free using a sampling method approved by the Associate Director.

2. All regulated commodities entering Arizona shall be unloaded at destination into a quarantine holding area and held undisturbed for at least five calendar days until the Department confirms the regulated commodities are pest-free.
3. An Arizona receiver of a regulated commodity shall establish a quarantine holding area approved by the Department that satisfies the following conditions:
   a. The floor of the holding area shall be composed of a permeable surface, such as sand or soil, and shall be free from debris, grass, and weeds;
   b. An outdoor quarantine holding area shall be at least 15 ft. from all masonry walls, property boundaries, and non-quarantined plants;
   c. The quarantine holding area shall be isolated from public access, and surrounded by a fence or other barrier; and
   d. The integrity and security of the holding area shall be maintained at all times.
4. A cutting or bareroot regulated commodity may be placed in a container during the quarantine holding period. If the Associate Director determines that the regulated commodity is infested with a pest, the regulated commodity, container, and soil shall be transported out-of-state or destroyed by a method approved by the Associate Director.
5. Pesticides and other chemicals shall not be applied to a regulated commodity in a quarantine holding area except under the direction and supervision of a Department inspector.

F. Disposition of violations.
If laboratory testing indicates a regulated commodity is infested with a pest, the regulated commodity shall be destroyed or transported out-of-state.

Historical Note

Former Rule, Quarantine Regulation 18. Amended effective April 26, 1976 (Supp. 76-2). Repealed effective December 19, 1980 (Supp. 80-6). Adopted effective August 1, 1985 (Supp. 85-2). Section R3-1-66 renumbered to R3-4-234 (Supp. 91-4). Section repealed; new Section made by final rulemaking at 7 A.A.R. 4434, effective September 24, 2001 (Supp. 01-3).

R3-4-235. Repealed

Historical Note

Adopted effective August 1, 1985 (Supp. 85-2). Section R3-1-66.01 renumbered to R3-4-235 (Supp. 91-4). Section repealed by final rulemaking at 7 A.A.R. 4434, effective September 24, 2001 (Supp. 01-3).

R3-4-236. Repealed

Historical Note

Adopted effective August 1, 1985 (Supp. 85-2). Section R3-1-66.02 renumbered to R3-4-236 (Supp. 91-4). Section repealed by final rulemaking at 7 A.A.R. 4434, effective September 24, 2001 (Supp. 01-3).

R3-4-237. Repealed

Historical Note

Adopted effective August 1, 1985 (Supp. 85-2). Section R3-1-66.03 renumbered to R3-4-237 (Supp. 91-4). Section repealed by final rulemaking at 7 A.A.R. 4434, effective September 24, 2001 (Supp. 01-3).

R3-4-238. Whitefly Pests

A. Definition.
"Pest" means:
1. Citrus whitefly, *Dialeurodes citri* (Ashm.);
2. Cloudy-winged whitefly, *Dialeurodes citrifolii* (Morgan);
3. Woolly whitefly, *Aleurothrixus floccosus* (Maskell).

B. Area under quarantine. Alabama, Arkansas, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, North Carolina, South Carolina, Texas, and Virginia.

C. Commodities covered. Plants and all plant parts, except fruit and seed, of the following genera and species:
Ailanthus,
Amplopsis,
Bignonia capreolata,
Choisya ternata,
Citrus,
Diospyros,
Eremocitrus,
Feijoa,
Ficus macrophyll,
Fortunella,
Gardenia,
Ilex,
Jasminum,
Lagerstroemia,
Ligustrum,
Maclura pomifera,
Melia,
Microcitrus,
Musa,
Osmanthus,
Plumaria,
Poncirus,
Prunus caroliniana,
Psidum,
Punica granatum,
Pyrus communis,
Sapindus mukorossi,
Smilax,
Syringa vulgaris, and
Viburnum

D. Restrictions. A person may ship a regulated commodity to Arizona from an area under quarantine if the shipment is accompanied by a certificate issued by a plant regulatory official of the origin state attesting that within five days before shipment:
1. A regulated commodity of the genera *Citrus*, *Eremocitrus*, *Fortunella*, *Microcitrus*, and *Poncirus* was treated with a chemical to kill the pests listed in subsection (A), and was visually inspected and found free of all live life stages of the pests listed in subsection (A).
2. A regulated commodity not listed in subsection (D)(1):
   a. Was treated with a chemical to kill the pests listed in subsection (A) and was visually inspected and found free of all live life stages of the pests listed in subsection (A), or
   b. Originated from a nursery with a pest management program recognized and monitored by the origin state and to control the pests listed in subsection (A), and was visually inspected and found free of all live life stages of the pests listed in subsection (A), or
   c. The regulated commodity is completely devoid of foliage and is exempt from treatment for the pests listed in subsection (A).

E. Disposition of regulated commodity not in compliance. A regulated commodity shipped into Arizona in violation of this

Section shall be destroyed, treated, or transported out-of-state as prescribed at A.R.S. Title 3, Chapter 2, Article 1.

Historical Note

Former Rule, Quarantine Regulation 19. Amended effective April 26, 1976 (Supp. 76-2). Amended effective August 15, 1989 (Supp. 89-3). Section R3-1-67 renumbered to R3-4-238 (Supp. 91-4). Amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Amended by final rulemaking at 12 A.A.R. 4065, effective December 4, 2006 (Supp. 06-4).

R3-4-239. Imported Fire Ants

A. Definitions.
"Pest" means any species of imported fire ants, including *Solenopsis invicta* and *Solenopsis richteri*.

B. Area under quarantine. A state or portion of a state listed in 7 CFR 301.81-3, 68 FR 5794, February 5, 2003, and any area a state declares infested. This material is incorporated by reference, on file with the Department and the Office of the Secretary State, and does not include any later amendments or editions.

C. Regulated commodities.
1. Soil, except potting soil shipped in an original container in which the potting soil is packaged after commercial preparation; and
2. All plants associated with soil, except:
   a. Plants that are maintained indoors year-round, and are not for sale; and
   b. Plants shipped bare-root and free of soil.

D. Restrictions.
1. A shipper of a regulated commodity shall unload a regulated commodity at destination into an approved quarantine holding area as prescribed in subsection (D)(2). The Department shall inspect and quarantine the regulated commodity as follows:
   a. Soil and plants associated with soil from an area under quarantine in subsection (B) shall be held at least three consecutive days, and
   b. Soil and plants associated with soil from an area under quarantine for nematodes under R3-4-234(B) shall be held at least five consecutive days.
2. An Arizona receiver of a regulated commodity shall establish a Department-approved quarantine holding area that meets the following specifications:
   a. The floor is of a permeable surface, such as sand or soil, and free from debris, grass, or weeds;
   b. The area is isolated from public access, surrounded by a fence or other barrier;
   c. The integrity and security of the area is maintained at all times; and
   d. If outdoors, the area is at least 15 feet from any masonry wall, property boundary, or non-quarantine plant.
3. A receiver shall apply a pesticide or other chemical to a regulated commodity located in a quarantine holding area only when directed and supervised by a Department inspector.

E. Disposition of commodity not in compliance. A regulated commodity shipped into Arizona in violation of this Section shall be destroyed or transported out-of-state by the owner and at the owner's expense.

Historical Note

Former Rule, Quarantine Regulation 20. Amended effective July 1, 1975 (Supp. 75-1). Amended effective April 26, 1976 (Supp. 76-2). Correction amendment effective April 26, 1976 included deletion of Arkansas (see subsection (C)) (Supp. 77-1). Amended effective June 16, 1977 (Supp. 77-3). Repealed effective June 19, 1978 (Supp. 78-3). New Section adopted effective December 22, 1989 (Supp. 89-4). Section R3-1-68 renumbered to R3-4-239 (Supp. 91-4). Amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Amended by final rulemaking at 9 A.A.R. 2095, effective August 2, 2003 (Supp. 03-2).

R3-4-240. Apple Maggot and Plum Curculio

A. Definitions. The following term applies to this Section:
"Pest" means:
1. Apple maggot, *Rhagoletis pomonella* (Walsh); or
2. Plum curculio, *Conotrachelus nenuphar.*

B. Area under quarantine. All states, territories, and districts of the United States.

C. Regulated commodities. The fresh fruit of the following plants:
Chaenomeles spp. (Quince),
Crataegus spp. (Hawthorne),
Malus spp. (Apple),
Prunus spp. (Apricot, Cherry, Nectarine, Peach, Plum, and Prune), and
Pyrus communis spp. (Pear).

D. Restrictions.
1. A person shall not ship into Arizona a regulated commodity that is produced in or shipped from an area under quarantine unless each lot or shipment is accompanied by a certificate issued by an official of the state of origin, attesting that the regulated commodity was:
   a. Held in an approved controlled atmosphere storage facility for a minimum of 90 continuous days at a maximum temperature of 38° F, or
   b. Held in an approved cold storage facility for a minimum of 40 continuous days at a maximum temperature of 32° F.
2. The Director may issue a permit to allow a regulated commodity from an area under quarantine to enter Arizona without treatment as prescribed in subsection (D)(1) if the commodity originates from an area:
   a. That is certified to be pest-free, or
   b. That is infested, but where an on-going pest eradication program exists that is acceptable to the Director of the Arizona Department of Agriculture.

E. Disposition of commodity not in compliance. A regulated commodity shipped into Arizona in violation of this Section shall be destroyed or transported out-of-state by the owner and at the owner's expense.

Historical Note

Former Rule, Quarantine Regulation 21. Amended effective December 5, 1974 (Supp. 75-1). Amended effective June 16, 1977 (Supp. 77-3). Section repealed, new Section adopted effective June 14, 1990 (Supp. 90-2). Section R3-1-69 renumbered to R3-4-240 (Supp. 91-4). Amended by final rulemaking at 9 A.A.R. 1046, effective May 5, 2003 (Supp. 03-1).

R3-4-241. Lethal Yellowing of Palms

A. Definitions. The following term applies to this Section:
"Pest" means:
1. A pathogen, a non-cultivable mollicute, causing lethal yellowing of palms; or
2. *Myndus crudus*, a planthopper that vectors the pathogen.

B. Area under quarantine.
1. In the state of Florida, the following counties: Broward, Collier, Hendry, Lee, Martin, Miami-Dade, Monroe, and Palm Beach.

2. In the state of Texas, the following counties: Cameron, Hidalgo, and Willacy.

C. Regulated commodities. All propagative parts of the following plants, except seed:
Aiphanes lindeniana,
Allagoptera arendria,
Andropogon virginicus (Broomsedge),
Arenga engleri,
Borassus flabellifer (Palmyra Palm),
Caryota mitis (Cluster Fishtail Palm),
Caryota rumphiana (Giant Fishtail Palm),
Chelyocarpus chuco,
Chrysalidocarpus cabadae, syn. *Dypsis cabadae* (Cabada Palm),
Cocos nucifera (Coconut Palm),
Corypha elata (Buri Palm),
Cynodon dactylon (Bermuda Grass),
Cyperus spp. (Sedges),
Dictyosperma album (Princess Palm),
Eremochloa ophiuroides (Centipede Grass),
Gaussia attenuata (Puerto Rican Palm),
Howea belmoreana (Belmore Sentry Palm),
Latania spp. (Latan Palm),
Livistona chinensis (Chinese Fan Palm),
Livistona rotundifolia (Javanese Fan Palm),
Mascarena verschaffeltii (Spindle Palm),
Nannorrhops ritchiana (Mazari Palm),
Neodypsis decaryi, syn. *Dypsis decaryi* (Triangle Palm),
Pandanus utilis (Screw Pine),
Panicum purpurascens (Para Grass),
Panicum bartowense,
Paspalum notatum (Bahia Grass),
Phoenix canariensis (Canary Island Date Palm),
Phoenix dactylifera (Date Palm),
Phoenix reclinata (Sengal Date Palm),
Phoenix rupicola (Cliff Date Palm),
Phoenix sylvestris (Wild Date Palm),
Phoenix zeylanica (Ceylon Date Palm),
Polyandrococos caudescons,
Pritchardia spp.,
Ravenea hildebrandtii,
Stenotapphrum secundatum (St. Augustine Grass),
Syagrus schizophylla
Trachycarpus fortunei (Windmill Palm),
Veitchia spp., and
Zoysia spp. (Zoysia Grass).

D. Restrictions. A person shall not ship into Arizona a regulated commodity that is produced in or shipped from an area under quarantine.

E. Disposition of commodity not in compliance. A regulated commodity shipped into Arizona in violation of this Section shall be destroyed or transported out-of-state by the owner and at the owner's expense.

Historical Note

Former Rule, Quarantine Regulation 22. Repealed effective April 25, 1977 (Supp. 77-2). New Section adopted effective December 22, 1989 (Supp. 89-4). Section R3-1-70 renumbered to R3-4-241 (Supp. 91-4). Amended by final rulemaking at 9 A.A.R. 1046, effective May 5, 2003 (Supp. 03-1).

R3-4-242. Brown Citrus Aphid

A. Area Under Quarantine: Hawaii and any county in Florida that, by notification from the Florida Department of Agriculture and Consumer Services, is infested with the brown citrus aphid.

B. Commodities covered: All plants, except seed and fruit.

C. Restrictions.
1. The species, subspecies, varieties, ornamental forms, and any hybrid having at least one ancestor of the following genera are prohibited from entering the state:
   a. *Citrus*,
   b. *Fortunella*, and
   c. *Poncirus*,
2. All other covered commodities, whether moved directly from the area under quarantine or by diversion or reconsignment from any other point, are prohibited from entering Arizona unless the following requirements are met:
   a. Aquatic plants are accompanied by an original certificate affirming that the commodity was inspected and found free of the pest within five days before shipment.
   b. Terrestrial plants are accompanied by an original certificate affirming that the commodity was treated, as prescribed in subsection (E), within five days before shipment.
   c. The certificate shall indicate:
      i. The common chemical name of the product's active ingredient,
      ii. The rate at which the product was applied, and
      iii. The treatment date.

D. The Director may issue a permit admitting a covered commodity subject to specific limitations, conditions, and provisions that eliminate the risk of the pest.

E. Treatment.
1. An application of a pesticide labeled for the treatment of aphids applied according to label instructions, or
2. Any other treatment approved by the Director.

Historical Note

Former Rule, Quarantine Regulation 23. Amended effective July 1, 1975 (Supp. 75-1). Correction (Supp. 76-5). Repealed effective April 25, 1977 (Supp. 77-2). Section R3-1-71 renumbered to R3-4-242 (Supp. 91-4). New Section adopted by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3).

R3-4-243. Repealed

Historical Note

Former Rule, Quarantine Regulation 24. Repealed effective April 25, 1977 (Supp. 77-2). Section R3-1-72 renumbered to R3-4-243 (Supp. 91-4).

R3-4-244. Regulated and Restricted Noxious Weeds

A. Definitions. In addition to the definitions provided in A.R.S. § 3-201, the following terms apply to this Section:
1. "Habitat" means any terrestrial or aquatic area within Arizona that is capable of sustaining plant growth.
2. "Infested area" means each individual container in which a pest is found or the specific area that harbors a pest.
3. "Regulated pest" means any of the following plant species, including viable plant parts (stolons, rhizomes, cuttings and seed, except agricultural, vegetable and ornamental seed for planting purposes), found within the state may be controlled to prevent further infestation or contamination:
   Cenchrus echinatus L. -- Southern sandbur,
   Cenchrus incertus M.A. Curtis -- Field sandbur,
   Convolvulus arvensis L. -- Field bindweed,
   Eichhornia crassipes (Mart.) Solms -- Floating water hyacinth,
   Medicago polymorpha L. -- Burclover,
   Pennisetum ciliare (L.) Link -- Buffelgrass,

Portulaca oleracea L. -- Common purslane,
Tribulus terrestris L. -- Puncturevine.

4. "Restricted pest" means any of the following plant species, including viable plant parts (stolons, rhizomes, cuttings and seed, except agricultural, vegetable and ornamental seed for planting purposes), found within the state shall be quarantined to prevent further infestation or contamination:

Acroptilon repens (L.) DC. -- Russian knapweed,
Aegilops cylindrica Host. -- Jointed goatgrass,
Alhagi pseudalhagi (Bieb.) Desv. -- Camelthorn,
Cardaria draba (L.) Desv. -- Globed-podded hoary cress (Whitetop),
Centaurea diffusa L. -- Diffuse knapweed,
Centaurea maculosa L. -- Spotted knapweed,
Centaurea solstitialis L. -- Yellow starthistle (St. Barnaby's thistle),
Cuscuta spp. -- Dodder,
Eichhornia crassipes (Mart.) Solms -- Floating water hyacinth,
Elytrigia repens (L.) Nevski -- Quackgrass,
Euryops sunbcarnosus subsp. *vulgaris* -- Sweet resinbush,
Halogeton glomeratus (M. Bieb.) C.A. Mey -- Halogeton,
Helianthus ciliaris DC. -- Texas blueweed,
Ipomoea triloba L. -- Three-lobed morning glory,
Linaria genistifolia var. *dalmatica* -- Dalmation toadflax,
Onopordum acanthium L. -- Scotch thistle.

B. Area under quarantine: All infested areas within the state.

C. The following commodities are hosts or carriers of the regulated or restricted pest:

1. All plants other than those categorized as a regulated or restricted pest;
2. Forage, straw, and feed grains;
3. Live and dead flower arrangements;
4. Ornamental displays;
5. Aquariums; and
6. Any appliance, construction or dredging equipment, boat, boat trailer or related equipment, or any other vehicle with soil attached or carrying plant debris.

D. The Department may quarantine any commodity, habitat, or area infested or contaminated with a regulated pest and notify the owner or carrier of the restrictions and treatments listed in subsections (F) and (G). If the regulated pest is not quarantined, the Department shall provide the grower with technical information on effective weed control activities through integrated pest management.

E. The Department shall quarantine any commodity, habitat, or area infested or contaminated with a restricted pest and shall notify the owner or carrier of the restrictions and treatments of the pest listed in subsections (F) and (G).

F. Restrictions.

1. No regulated or restricted pest or commodity infested or contaminated with a regulated or restricted pest shall be moved to a non-infested area unless the Director issues a permit for the transporting or propagating of the pest.
2. An owner or the owner's representative shall notify the Department at least two working days in advance of moving contaminated equipment from an infested area.
3. The Department may inspect all equipment within two working days after a request to inspect the equipment is made if the equipment:
   a. Has been moved into or through a non-infested area;
   b. Has not been treated; or
   c. Has been used to harvest an infested crop within the past 12 months.

G. Treatments.

1. An owner or the owner's representative shall treat all soil and debris from equipment used in a quarantined area until it is free of the regulated or restricted pest before the equipment is moved. Removal or destruction of the restricted or regulated pest shall be accomplished through one of the following methods:
   a. Autoclaving.
      i. Dry heat. The commodity shall be heated for 15 minutes at 212° F.
      ii. Steam heat. The commodity shall be heated for 15 minutes at 212° F;
   b. Fumigating with ethylene oxide, chamber only: The commodity shall be fumigated with 1,500 mg/L for four hours in a chamber pre-heated to 115-125° F;
   c. High-pressure water spray;
   d. Crushing;
   e. Incinerating; or
   f. Burying in a sanitary landfill to a depth of six feet.
2. An owner or the owner's representative shall treat an infested area or habitat, including the area within the crop, rangeland, roadside, or private property, with treatments based on an integrated pest management program appropriate to the commodity. The treatments shall take place under the direction of an inspector and shall include:
   a. Reshipment from the state;
   b. Manual removal;
   c. Application of a herbicide;
   d. Biological control including insects, fungi, nematodes, or microbes; or
   e. Any other treatment approved by the Director.

Historical Note

Former Rule, Quarantine Regulation 25. Repealed effective June 19, 1978 (Supp. 78-3). Section R3-1-73 renumbered to R3-4-244 (Supp. 91-4). New Section adopted effective July 10, 1995 (Supp. 95-3). Amended effective June 4, 1998 (Supp. 98-2). Amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Amended by final rulemaking at 6 A.A.R. 2082, effective May 15, 2000 (Supp. 00-2). Amended by final rulemaking at 11 A.A.R. 5315, effective February 4, 2006 (Supp. 05-4).

R3-4-245. Prohibited Noxious Weeds

A. Definition. In addition to the definitions provided in A.R.S. § 3-201, the following apply to this Section:

1. "Habitat" means any terrestrial or aquatic area within Arizona that is capable of sustaining plant growth.
2. "Infested area" means each individual container in which a pest is found, the specific area that harbors the pest, or any shipment that has not been released to the receiver and is infested with a pest.
3. "Pest" means any of the following plant species, including viable plant parts (stolons, rhizomes, cuttings and seed, except agricultural, vegetable and ornamental seed for planting purposes), that are prohibited from entering the state:

Acroptilon repens (L.) DC. -- Russian knapweed,
Aegilops cylindrica Host. -- Jointed goatgrass,
Alhagi pseudalhagi (Bieb.) Desv. -- Camelthorn,
Alternanthera philoxeroides (Mart.) Griseb. -- Alligator weed,

Cardaria pubescens (C.A. Mey) Jarmolenko -- Hairy whitetop,
Cardaria chalepensis (L.) Hand-Muzz -- Lens podded hoary cress,
Cardaria draba (L.) Desv. -- Globed-podded hoary cress (Whitetop),
Carduus acanthoides L. -- Plumeless thistle,
Cenchrus echinatus L. -- Southern sandbur,
Cenchrus incertus M.A. Curtis -- Field sandbur,
Centaurea calcitrapa L. -- Purple starthistle,
Centaurea iberica Trev. ex Spreng. -- Iberian starthistle,
Centaurea squarrosa Willd. -- Squarrose knapweed,
Centaurea sulphurea L. -- Sicilian starthistle,
Centaurea solstitialis L. -- Yellow starthistle (St. Barnaby's thistle),
Centaurea diffusa L. -- Diffuse knapweed,
Centaurea maculosa L. -- Spotted knapweed,
Chondrilla juncea L. -- Rush skeletonweed,
Cirsium arvense L. Scop. -- Canada thistle,
Convolvulus arvensis L. -- Field bindweed,
Coronopus squamatus (Forskal) Ascherson -- Creeping wartcress (Coronopus),
Cucumis melo L. var. Dudaim Naudin -- Dudaim melon (Queen Anne's melon),
Cuscuta spp. -- Dodder,
Drymaria arenarioides H.B.K. -- Alfombrilla (Lightningweed),
Eichhornia azurea (SW) Kunth. -- Anchored water hyacinth,
Eichhornia crassipes (Mart.) Solms – Floating water hyacinth,
Elytrigia repens (L.) Nevski -- Quackgrass,
Euphorbia esula L. -- Leafy spurge,
Halogeton glomeratus (M. Bieb.) C.A. Mey -- Halogeton,
Helianthus ciliaris DC. -- Texas blueweed,
Hydrilla verticillata Royale -- Hydrilla (Florida-elodea),
Ipomoea spp. -- Morning glory. All species except *Ipomoea carnea*, Mexican bush morning glory; *Ipomoea triloba*, three-lobed morning glory (which is considered a restricted pest); and *Ipomoea aborescens*, morning glory tree,
Ipomoea triloba L. -- Three-lobed morning glory,
Isatis tinctoria L. -- Dyers woad,
Linaria genistifolia var. *dalmatica* -- Dalmation toadflax,
Lythrum salicaria L. -- Purple loosestrife,
Medicago polymorpha L. -- Burclover,
Nassella trichotoma (Nees.) Hack. -- Serrated tussock,
Onopordum acanthium L. -- Scotch thistle,
Orobanche ramosa L. -- Branched broomrape,
Panicum repens L. -- Torpedo grass,
Peganum harmala L. -- African rue (Syrian rue),
Pennisetum ciliare (L.) Link – Buffelgrass,
Portulaca oleracea L. -- Common purslane,
Rorippa austriaca (Crantz.) Bess. -- Austrian fieldcress,
Salvinia molesta -- Giant Salvinia,
Senecio jacobaea L. -- Tansy ragwort,
Solanum carolinense L. -- Carolina horsenettle,
Sonchus arvensis L. -- Perennial sowthistle,
Solanum viarum Dunal -- Tropical Soda Apple,
Stipa brachychaeta Godr. -- Puna grass,
Striga spp. -- Witchweed,
Trapa natans L. -- Water-chestnut,
Tribulus terrestris L. -- Puncturevine.

B. Area under quarantine: All states, districts, and territories of the United States except Arizona.

C. The following commodities are hosts or carriers of the pest:
1. All plants and plant parts other than those categorized as a pest;
2. Forage, straw, and feed grains;
3. Live or dead flower arrangements;
4. Ornamental displays;
5. Aquariums; and
6. Any appliance, construction or dredging equipment, boat, boat trailer or related equipment, or any other vehicle with soil attached or carrying plant debris.

D. The Department shall quarantine any commodity, habitat, or area infested or contaminated with a pest and shall notify the owner or carrier of the methods of removing or destroying the pest from the commodity, habitat, or area. The Department shall reject any shipment not released to the receiver and reship to the shipper.

E. Restrictions:
1. No pest or commodity infested or contaminated with a pest shall be admitted into the state unless the Director issues a permit for the transporting or propagating of the pest.
2. The Department shall regulate the movement of the commodity out of a quarantined area within the state until the pest is eradicated. Any shipment or lot of a commodity infested or contaminated with a pest arriving in the state in violation of this quarantine shall, according to A.R.S. § 3-205(A), be immediately reshipped from the state, or treated or destroyed using one of the following methods:
   a. The commodity shall be fumigated with 1,500 mg/L of ethylene oxide for four hours in a chamber preheated to 115-125° F;
   b. Incinerating;
   c. Burying in a sanitary landfill to a depth of six feet;
   d. Application of a herbicide; or
   e. Any other treatment approved by the Director.

Historical Note

Former Rule, Quarantine Regulation 26. Amended effective June 19, 1978 (Supp. 78-3). Amended subsection (B) effective May 2, 1986 (Supp. 86-3). Section R3-1-74 renumbered to R3-4-245 (Supp. 91-4). Section repealed, new Section adopted effective July 10, 1995 (Supp. 95-3). Amended effective June 4, 1998 (Supp. 98-2). Amended by final rulemaking at 6 A.A.R. 2082, effective May 15, 2000 (Supp. 00-2). Amended by final rulemaking at 11 A.A.R. 5315, effective February 4, 2006 (Supp. 05-4).

R3-4-246. Caribbean Fruit Fly

A. Definitions. The following term applies to this Section:
"Pest" means all life stages of the Caribbean fruit fly, *Anastrepha suspensa*.

B. Area under quarantine.
1. In the state of Florida, the following counties: Alachua, Brevard, Broward, Charlotte, Citrus, Collier, DeSoto, Duval, Glades, Hardee, Hendry, Hernando, Highlands, Hillsborough, Indian River, Lake, Lee, Manatee, Martin, Miami-Dade, Monroe, Okeechobee, Orange, Osceola, Palm Beach, Pasco, Pinellas, Polk, Putnam, St. Johns, St. Lucie, Sarasota, Seminole, Sumter, and Volusia.
2. The Commonwealth of Puerto Rico.

C. Regulated commodities.

1. The fresh fruit of the following plants:
Actinidia chinensis (Kiwi),
Annona glabra (Pond Apple),
Annona hybrid,
Annona squamosa (Sugar Apple),
Atalantia citriodes,
Averrhoa carambola (Carambola),
Blighia sapida (Akee),
Canella winteriana (Wild Cinnamon),
Capsicum frutesceas (Bell Pepper),
Carica papaya (Papaya),
Carissa grandiflora (Natal Plum),
Casimiroa edulis (White Sapote),
Chrysobalanus icaco (Cocoplum),
Citrus aurantiifolia (Lime),
Citrus aurantium (Sour Orange),
Citrus limonia (Rangpur Lime),
Citrus nobilis 'unshu' x *Fotunella* sp. (Jack Orangequat),
Citrus paradisi (Grapefruit),
Citrus paradisi x *C. reticulata* (Tangelo),
Citrus reticulata (Tangerine),
Citrus sinensis (Sweet Orange),
Citrus sinensis x *C. reticulata* (Temple Orange),
Clausena lansium (Wampi),
Dimocarpus longan (Longan),
Diospyros blancoi (Velvet Apple or Velvet Persimmon),
Diospyros khaki (Japanese Persimmon),
Dovyalis caffra (Kei Apple),
Dovyalis hebecarpa (Ceylon Gooseberry),
Drypetes lateriflora (Guiana Plum),
Eriobotrya japonica (Loquat),
Eugenia aggregata (Cherry of the Rio Grande),
Eugenia brasiliensis (Grumichama),
Eugenia coronata,
Eugenia ligustrina,
Eugenia luschnathiana (Pitomba),
Eugenia uniflora (Surinam Cherry),
Ficus altissima,
Ficus carica (Fig),
Flacourtia indica (Governor's Plum),
Fortunella spp. (Kumquat),
Garcinia livingstonei (Imbe),
Garcinia xanthochymus,
Litchi chinensis (Lychee),
Lycopersicon esculentum (Tomato),
Malpighia glabra (Barbados Cherry),
Malus sylvestris (Apple),
Mangifera indica (Mango),
Manilkara jaimiqui spp. *Emarginata* (Wild Dilly),
Manilkara roxburghiana,
Manilkara zapota (Sapodilla),
Momordica charantia (Wild Balsam Apple),
Muntingia calabura (Calbur),
Murraya paniculata (Orange Jasmine),
Myciaria cauliflora (Jaboticaba),
Myrcianthes fragrans,
Myricaria glomerata,
Persea americana (Avocado),
Pimenta dioica (Allspice),
Pouteria campechiana (Egg Fruit),
Prunus persica (Nectarine),
Prunus persica (Peach),
Pseudanamomis umbellulifera,
Psidium spp. (Guava),
Punica granatum (Pomegranate),
Pyrus cummunis (Pear),
Pyrus pyrifolia (Japanese Pear),
Pyrus pyrifolia x *Pyrus communis* (Kieffer Pear),
Rheedia aristata,
Rubus hybrid (Blackberry),
Severinia buxifolia (Box Orange),
Spondias cytherea (Otaheite Apple),
Synsepalum dulcificum (Miracle Fruit),
Syzygium cumini (Jambolan Plum),
Syzygium jambos (Rose Apple),
Syzygium samarangense (Java Apple),
Terminalia catappa (Tropical Almond),
Terminalia muelleri,
Trevisia palmata,
Triphasia trifolia (Limeberry),
X *Citrofortunella floridana* (Limequat), and
X *Citrofortunella mitis* (Calamondin).
2. Soil or planting media within the drip area of plants producing, or that have produced, a regulated commodity.

D. Restrictions. A regulated commodity produced in or shipped from an area under quarantine is prohibited entry into Arizona unless each lot or shipment is accompanied by a certificate issued by an official of the state of origin, affirming compliance with one of the following:
1. Citrus fruit (*Citrus* spp. and *Fortunella* spp.) has been fumigated with methyl bromide ("Q" label only) for a minimum of two hours under the following conditions:

Pulp Temperature	**Rate per 1000 cu. ft.**
No less than 60° F to 79° F	3 pounds
80° F or above	2 1/2 pounds

2. Non-citrus fruit has been treated in compliance with a treatment plan approved by the Director.

E. Disposition of commodity not in compliance. A regulated commodity shipped into Arizona in violation of this Section shall be destroyed or transported out-of-state by the owner and at the owner's expense.

Historical Note

Adopted effective July 1, 1975 (Supp. 75-1). Correction (Supp. 76-1). Amended effective May 10, 1988 (Supp. 88-2). Section R3-1-75 renumbered to R3-4-246 (Supp. 91-4). Amended by final rulemaking at 9 A.A.R. 2098, effective August 2, 2003 (Supp. 03-2).

R3-4-247. Repealed

Historical Note

Amended effective April 26, 1976 (Supp. 76-2). Amended effective June 16, 1977 (Supp. 77-3). Repealed effective June 19, 1978 (Supp. 78-3). Section R3-1-76 renumbered to R3-4-247 (Supp. 91-4).

R3-4-248. Japanese beetle

A. Definitions.
1. "Host commodities" means the commodities listed in the JBHP, Appendix 5.
2. "JBHP" means the U.S. Domestic Japanese Beetle Harmonization Plan, adopted by the National Plant Board on August 19, 1998, and revised September 5, 2000.
3. "Pest" means the Japanese beetle, *Popillia japonica* (Newman).

B. Area under quarantine: All areas listed in the JBHP, which is incorporated by reference, does not include any later amendments or editions, and is on file with the Department, the Office of the Secretary of State, and the National Plant Board

at www.aphis.usda.gov/npb. The incorporated material includes the following changes:
1. Appendix 1, delete the words "(except sod)."
2. Appendix 5, definition of host commodities, delete the words "grass sod."

C. Host commodities covered. All commodities, except grass sod, listed in the JBHP.

D. An out-of-state grower who imports a host commodity into Arizona shall comply with the JBHP, except as provided under subsection (E).

E. Restrictions on importation.
1. An out-of-state grower shall not import into Arizona a host commodity under subsection (C) from an area under quarantine unless the commodity is accompanied by an original certificate issued by an official of the origin state ensuring compliance with the requirements of the JBHP, Appendix 1.
2. The Associate Director may admit grass sod from an out-of-state grower for shipment to Arizona if:
   a. The out-of-state grower requests an exception agreement from the Department;
   b. The out-of-state grower, the state plant regulatory official of the origin state, and the Associate Director sign an agreement that includes the following terms:
      i. The out-of-state grower shall ship sod grown only in a Japanese beetle-free county;
      ii. The origin state's plant regulatory official shall place and monitor Japanese beetle traps on the grass sod farm during the agreement period. At least one trap shall be placed on each 10 acres of land. A buffer zone of a one-mile radius shall be established around the grass sod farm, and two traps per square mile shall be placed in the buffer zone. The Department shall revoke the agreement if the origin state documents that one or more Japanese beetles are detected in any trap;
      iii. The origin state's plant regulatory official or designee shall inspect sod before shipment to ensure it is free of the pest; and
      iv. The out-of-state grower shall ship sod to Arizona only through the ports of entry on I-10 or I-40.
   c. Both the out-of-state grower and the origin state's plant regulatory official shall perform any other requirement established by the Associate Director to ensure the grass sod is free from all life stages of Japanese beetle.
3. Exemptions from importation ban:
   a. Privately-owned houseplants grown indoors; and
   b. Commodities that are treated by the grower for Japanese beetle may be imported into Arizona if the Associate Director approves the treatment method before shipment.

Historical Note

Adopted effective June 16, 1977 (Supp. 77-3). Section R3-1-77 renumbered to R3-4-248 (Supp. 91-4). Amended by final rulemaking at 7 A.A.R. 5345, effective November 8, 2001 (Supp. 01-4).

ARTICLE 3. NURSERY CERTIFICATION PROGRAM

R3-4-301. Nursery Certification

A. Definitions. The following terms apply to this Section.

"Associate Director" means the Associate Director of the Arizona Department of Agriculture's Plant Services Division.

"Certificate" means a document issued by the Director, Associate Director or by a Department inspector stating that the nursery stock has been inspected and complies with the criteria set forth by an agricultural agency of any state, county, or commonwealth.

"Certificate holder" means a person who holds a certificate issued in accordance with this Section.

"Collected nursery stock" means nursery stock that has been dug or gathered from any site other than a nursery location.

"Commercially clean" means nursery stock offered for sale is in a healthy condition and, though common pests may be present, they exist at levels that pose little or no risk.

"Common pest" means a pest, weed, or disease that is not under a state or federal quarantine or eradication program and is of general distribution within the state.

"Director" means the Director of the Arizona Department of Agriculture.

"General nursery stock inspection certification" means an inspection carried out at the request of a person for the purpose of meeting the general nursery inspection requirements of another state.

"Nursery location" means real property with one physical address, upon which nursery stock is propagated, grown, sold, distributed, or offered for sale.

"Quarantine pest" means an economically important pest that does not occur in the state or that occurs in the state but is not widely distributed or is being officially eradicated.

"Single shipment nursery stock inspection certification" means a visit to a single location by a Department inspector to certify one or more shipments of nursery stock for compliance with the quarantine requirements of the receiving state, county, or commonwealth.

B. General nursery stock inspection certification. A person may apply for general nursery stock inspection certification by submitting to the Department the application described in subsection (E) for each nursery location. The applicant shall submit a $50 inspection fee to the Department at the time of inspection for each nursery location. Each nursery location shall be inspected and certified separately. An application for initial certification may be submitted at any time. A certificate will be valid for one year, and may be renewed. A renewal application shall be submitted each year by February 15.
1. The Department shall issue a general nursery stock inspection certificate to the applicant if, following a Department inspection, the nursery stock is found free of quarantine pests, and commercially clean of common pests that are adversely affecting the nursery stock.
   a. The Department shall only certify nursery stock that is found free of quarantine pests. The applicant shall not remove from the nursery any nursery stock that is found infested with a quarantine pest until a Department inspector determines that the pest has been eliminated.
   b. The Department shall restrict the movement of any nursery stock found infested with a common pest that a Department inspector determines is adversely affecting the nursery stock. The applicant shall

establish a treatment program to control the pest and shall not remove the infested nursery stock from the nursery until a Department inspector determines that the pest has been controlled.

2. A certificate holder shall ensure that a nursery with a general nursery stock inspection certificate remains free of quarantine pests and commercially clean of common pests that are adversely affecting the nursery stock throughout the period that the certificate is valid.
3. A certificate holder shall not distribute, transport, or sell nursery stock interstate if it is infested with a quarantine pest or a common pest that is adversely affecting the nursery stock.
4. A certificate holder may reproduce a general nursery stock inspection certificate without the Department's permission for nursery use.
5. A certificate holder shall ensure that the nursery's general nursery stock inspection certificate accompanies each shipment of nursery stock that is moved out of the state.
6. A certificate holder shall maintain all invoices or other shipping documents for shipments received by and shipped from the nursery for up to one year. The certificate holder shall make the documents available to the Department upon request, as authorized by A.R.S. § 3-201.01(A)(6).
7. The Department shall inspect a nursery with a general nursery stock inspection certificate at any time during the certificate period to verify compliance with this Section.
8. A general nursery stock inspection certificate expires on December 31 of each year unless renewed, suspended, or revoked as provided in this Section.
9. A person with a general nursery stock inspection certificate may also need to obtain a special nursery stock inspection certificate to meet a specific quarantine entry requirement of another state, as prescribed in subsection (C).

C. Special nursery stock inspection certification. A person may apply for special nursery stock inspection certification to meet specific quarantine entry requirements of another state that are not addressed by the general nursery stock inspection certificate described in subsection (B). The applicant shall submit to the Department the application described in subsection (E) and a $50 inspection fee for each nursery location.

1. An applicant shall ensure that the applicant's nursery stock is free of quarantine pests as required by the receiving state and commercially clean of common pests that are adversely affecting the nursery stock. The Department shall not certify nursery stock that is infested with a quarantine pest until a Department inspector determines that the pest has been eliminated. The Department shall not certify nursery stock that is infested with a common pest that a Department inspector determines is adversely affecting the nursery stock.
2. A certificate holder shall not reproduce or duplicate a special nursery stock inspection certificate without written permission from the Department.
3. A special nursery stock inspection certificate is valid for one year from the issue date unless the receiving state requires a shorter certification period.

D. Single shipment nursery stock inspection certification. A person may apply for a single shipment nursery stock inspection certification to meet the entry requirements of another state by submitting to the Department the application described in subsection (E) with a $50 inspection fee.

1. An applicant for a single shipment nursery stock inspection certificate shall ensure that the nursery stock in each shipment is free from quarantine pests, as required by the receiving state, and commercially clean of common pests that are adversely affecting the nursery stock. The Department shall not certify nursery stock that is infested with a quarantine pest until a Department inspector determines that the pest has been eliminated. The Department shall not certify nursery stock that is infested with a common pest that a Department inspector determines is adversely affecting the nursery stock until the pest has been controlled.
2. A single shipment nursery stock inspection certificate is valid for seven calendar days following the inspection date. A certificate holder may apply for a new certificate if the original certificate expires before the shipment leaves Arizona.
3. A certificate holder shall not reproduce or duplicate a single shipment nursery stock inspection certificate.
4. A person who has obtained a single shipment nursery stock inspection certificate for collected nursery stock shall retain a record, for at least one year from the shipment date, of the street address from which each plant in a shipment was collected. The person shall provide the collected nursery stock record to the Department upon request.

E. Application. A person applying for a certificate under this Section shall provide the following information on a form obtained from the Department:

1. Applicant's name, nursery name, mailing address, telephone and fax numbers, and e-mail address, as applicable;
2. Location at which inspection is to be made, by legal description or physical address;
3. Number of acres, structures, or vehicles to be inspected, as applicable;
4. For shipping, the state, county, or commonwealth of planned destination, the category of inspection, and the nursery stock to be certified;
5. Applicant's Social Security number or tax identification number; and
6. Applicant's signature and date of signature.

F. Based upon the circumstances of each case, the Associate Director may:

1. Refuse to issue a certificate if, after inspection, the Associate Director determines that an applicant has not met a requirement for certification.
2. Revoke a certificate for a violation of a condition of the certificate.
3. Suspend, for a period of up to 90 days, a certificate for misuse or misrepresentation related to the certificate.
4. Refuse to issue or suspend a certificate issued under this Section if the applicant or certificate holder refuses to provide the Department with documents that demonstrate the ownership, origin, or destination of nursery stock presented for certification.

G. Nothwithstanding subsections (B) through (D), during fiscal year 2014, an applicant for nursery stock inspection certification shall pay the following fee:

1. For general certification, $250.
2. For single shipment certification, $50 for the first lot plus $10 for each additional lot per Department site trip.

Historical Note

Adopted effective January 17, 1989 (Supp. 89-1). Section R3-4-301 renumbered from R3-1-301 (Supp. 91-4). Section repealed; new Section made by final rulemaking at 12 A.A.R. 1378, effective June 4, 2006 (Supp. 06-2). Amended by exempt rulemaking at 16 A.A.R. 1336, effective June 29, 2010 (Supp. 10-2). Amended by exempt rulemaking at 17 A.A.R. 1761, effective July 20, 2011 (Supp. 11-3). Amended by exempt rulemaking at 18 A.A.R. 2063, effective August 2, 2012 (Supp. 12-3). Amended by exempt rulemaking at 19 A.A.R. 3143, effective September 14, 2013 (Supp. 13-3).

R3-4-302. Repealed

Historical Note

Adopted effective January 17, 1989 (Supp. 89-1). Section R3-4-302 renumbered from R3-1-301 (Supp. 91-4). Section repealed by final rulemaking at 12 A.A.R. 1378, effective June 4, 2006 (Supp. 06-2).

R3-4-303. Repealed

Historical Note

Adopted effective January 17, 1989 (Supp. 89-1). Section R3-4-303 renumbered from R3-1-303 (Supp. 91-4). Section repealed by final rulemaking at 12 A.A.R. 1378, effective June 4, 2006 (Supp. 06-2).

R3-4-304. Repealed

Historical Note

Adopted effective January 17, 1989 (Supp. 89-1). Section R3-4-304 renumbered from R3-1-304 (Supp. 91-4). Section repealed by final rulemaking at 12 A.A.R. 1378, effective June 4, 2006 (Supp. 06-2).

R3-4-305. Repealed

Historical Note

Adopted effective January 17, 1989 (Supp. 89-1). Section R3-4-305 renumbered from R3-1-305 (Supp. 91-4). Section repealed by final rulemaking at 12 A.A.R. 1378, effective June 4, 2006 (Supp. 06-2).

R3-4-306. Repealed

Historical Note

Adopted effective January 17, 1989 (Supp. 89-1). Section R3-4-306 renumbered from R3-1-306 (Supp. 91-4). Section repealed by final rulemaking at 12 A.A.R. 1378, effective June 4, 2006 (Supp. 06-2).

R3-4-307. Repealed

Historical Note

Adopted effective January 17, 1989 (Supp. 89-1). Section R3-4-307 renumbered from R3-1-307 (Supp. 91-4). Repealed effective April 11, 1994 (Supp. 94-2).

ARTICLE 4. SEEDS

R3-4-401. Definitions

In addition to the definitions provided in A.R.S. § 3-231, the following shall apply to this Article:

1. “Blend” means seed consisting of more than one variety of a kind, with each variety in excess of five percent by weight of the whole.
2. “Brand” means a word, name, symbol, number, or design used to identify seed of one person to distinguish it from seed of another person.
3. “Certifying agency” means:
   a. An agency authorized under the laws of this state to officially certify seed and that has standards and procedures approved by the U.S. Secretary of Agriculture to assure the varietal purity and identity of the seed certified, or
   b. An agency of a foreign country determined by the U.S. Secretary of Agriculture to adhere to procedures and standards for seed certification comparable to the procedures and standards adhered to generally by seed-certifying agencies under subsection (a) of this definition.
4. “Coated seed” means seed that has been covered with a substance that changes the size, shape, or weight of the original seed. Seed coated with ingredients such as rhizobia, dyes, and pesticides is not coated seed.
5. “Conditioning” or “conditioned” means drying, cleaning, scarifying, and other operations that could change the purity or germination of the seed and require the seed lot to be retested to determine the label information.
6. “Dormant” means viable seed, excluding hard seed, that fails to germinate when provided the specified germination conditions for that kind of seed.
7. “Federal Seed Act” means the federal law at 7 U.S.C. 1551-1611 and regulations promulgated under the Act: 20 CFR part 201.
8. “Flower seeds” means seeds of herbaceous plants grown for their blooms, ornamental foliage, or other ornamental parts, and commonly known and sold under the name of flower or wildflower seeds in this state.
9. “Germination” means the emergence and development from the seed embryo of those essential structures that, for the kind of seed in question, are indicative of the ability to produce a normal plant under favorable conditions.
10. “Hard seeds” means seeds that remain hard at the end of the prescribed germination test period because they have not absorbed water due to an impermeable seed coat.
11. “Inert matter” means all matter that is not seed, including broken seeds, sterile florets, chaff, fungus bodies, and stones.
12. “Mixture”, “mix”, or “mixed” means seed consisting of more than one kind, each in excess of five percent by weight of the whole.
13. “Mulch” means a protective covering of any suitable substance placed with seed that acts to retain sufficient moisture to support seed germination, sustain early seedling growth and aid in preventing soil moisture evaporation, control of weeds, and erosion prevention.
14. “Origin” means the state where the seed was grown, or if not grown in the United States, the country where the seed was grown.
15. “Other crop seed” means seeds of plants grown as crops other than the kind or variety included in the pure seed, as determined by methods defined in this Article.
16. “Pure live seed” means the product of the percent of germination plus hard or dormant seed multiplied by the percent of pure seed divided by 100. The result is expressed as a whole number.
17. “Pure seed” means a kind of seed excluding inert matter and all other seed not of the kind being considered.
18. “Replacement date sticker” means a sticker on a label that displays a new test date.
19. “Retail” means sales that are not intended for agricultural use and are prepared for use by a consumer in home gardens or household plantings only.
20. “Seed count” means the number of seeds per unit weight in a container.
21. “Seizure” means taking possession of seed pursuant to a court order.
22. “Wholesale” means sales of seeds that are intended for agricultural use normally in quantities for resale, as by an agricultural retail merchant and are not prepared for use in home gardening or household plantings.

23. "Working sample" means the number of seeds required under §§ 402 and 403 of the Federal Seed Act.

Historical Note

Former Rule, Arizona Seed Regulation 1. Amended effective August 31, 1981 (Supp. 81-4). Former Section R3-4-110 renumbered without change as Section R3-4-401 (Supp. 89-1). Section R3-4-401 renumbered from R3-1-401 (Supp. 91-4). Section repealed, new Section adopted effective July 10, 1995 (Supp. 95-3). Amended by final rulemaking at 13 A.A.R. 1464, effective June 2, 2007 (Supp. 07-2).

R3-4-402. Labeling

A. General requirements:
1. Blank spaces or the words "free or none" mean "0" and "0.00%" for the purpose of applying the tolerances prescribed in this Article.
2. Labeling for purity and germination shall not show higher results than actually found by test.
3. The terms "foundation seed," "registered seed," and "certified seed" are authorized for use on seed certified by a seed certifying agency under the laws of Arizona as delineated in R3-4-405.
4. Relabeling. Any person relabeling seed in its original container shall include the following information on a label or a replacement date sticker:
   a. The calendar month and year the germination test was completed to determine the germination percentage and the sell-by date as required by subsection (C)(3)(i)(iv) or (C)(5)(c)(i),
   b. The same lot designation as on the original labels, and
   c. The identity of the person relabeling the seed if different from the original labeler.
5. Labeling of seed distributed to wholesalers. After seed has been conditioned, a labeler shall ensure the seed is labeled as follows:
   a. When supplied to a retailer or consumer, each bag or bulk lot must be completely labeled.
   b. When supplied to a wholesaler, if each bag or other container is clearly identified by a lot number permanently displayed on the container or if the seed is in bulk, the labeling of seed may be by invoice.
   c. When supplied to a wholesaler, if each bag or container is not identified by a lot number, it must carry complete labeling.
6. Seeds for sprouting. All labels of seeds sold for sprouting for salad or culinary purposes shall indicate the following information:
   a. Commonly accepted name of kind or kinds;
   b. Lot number;
   c. Percentage by weight of each pure seed component in excess of 5 percent of the whole, other crop seeds, inert matter, and weed seeds, if occurring;
   d. Percentage of germination of each pure seed component;
   e. Percentage of hard seed, if present; and
   f. The calendar month and year the germination test was completed to determine the percentages in subsections (c), (d) and (e).

B. Kind, variety, or type.
1. All agricultural seeds sold in this state, except as stated in subsection (B)(2), shall be labeled to include the recognized variety name or type or the words "Variety not stated." A brand is not a kind and variety designation and shall not be used instead of a variety name.
2. All cotton planting seed sold, offered for sale, exposed for sale, or transported for planting purposes in this state, shall have a label that includes both kind and variety.

C. Agricultural, vegetable, or flower seeds that is sold, offered for sale, or exposed for sale within this state shall bear on each container a plainly written or printed label or tag in English. No modifications or disclaimers shall be made to the required label information in the labeling or on another label attached to the container. No misleading information shall appear on the label. The label shall include the following information:
1. For agricultural, vegetable, and flower seeds that have been treated, the following is required and may appear on a separate label:
   a. Language indicating that the seed has been treated;
   b. The commonly-accepted chemical name of the applied substance or a description of the process used;
   c. If a substance that is harmful to human or animals is present with the seed, a caution statement such as "Do not use for food, feed, or oil purposes." The caution for highly toxic substances shall be a poison statement and symbol; and
   d. If the seed is treated with an inoculant, the date of expiration, which is the date beyond which the inoculant is not to be considered effective.
2. For agricultural seeds, except for lawn and turf grass seed and mixtures of lawn and turf grass seed as provided in subsection (C)(3); for seed sold on a pure live seed basis as provided in subsection (C)(7); and for hybrids that contain less than 95 percent hybrid seed as provided in subsection (C)(8):
   a. The name of the kind and variety for each agricultural seed component in excess of five percent of the whole and the percentage by weight of each. If the variety of the kinds generally labeled as a variety designated in this Article is not stated, the label shall show the name of the kind and the words, "variety not stated." Hybrid seed shall be labeled as hybrid;
   b. Lot number or other lot identification;
   c. Origin of alfalfa, red clover, and field corn (except hybrid corn) or if the origin is unknown, a statement that the origin is unknown;
   d. Percentage by weight of all weed seeds;
   e. The name and rate of occurrence per pound of each kind of restricted noxious weed seed present;
   f. Percentage by weight of agricultural seeds other than those required to be named on the label. Agricultural seeds may be designated as "crop seeds;"
   g. Percentage by weight of inert matter;
   h. The sum total of weight identified in subsections (a), (d), (f), and (g) shall equal 100 percent;
   i. For each named agricultural seed:
      i. Percentage germination, excluding hard seed;
      ii. Percentage of hard seeds, if present; and
      iii. The calendar month and year the test was completed to determine the percentages. The statement "total germination and hard seed" may be included following the percentages required under subsections (i) and (ii).
   j. Net weight of seed in the container or seed count per unit weight; and
   k. Name and address of the labeler, or the person who sells, offers, or exposes the seed for sale within this state.
3. For lawn and turf grass seed and lawn and turf grass seed mixtures:

a. For single kinds, the name of the kind or kind and variety and the percentage by weight.
b. For mixtures, the word “mix, “mixed”, or “mixture” or “blend” shall be stated with the name of the mixture, along with the commonly accepted name of each kind or kind and variety of each agricultural seed component in excess of five percent of the whole and the percentages by weight.
c. The percentage by weight of each kind of pure seed shall be listed in order of its predominance and in columnar form. The heading “pure seed” and “germination” or “germ” shall be placed consistent with generally accepted industry practices.
d. Percentage by weight of agricultural seed other than those required to be named on the label which shall be designated as “crop seed.”
e. The percentage by weight of inert matter for lawn and turf grass shall not exceed ten percent, except that 15 percent inert matter is permitted in Kentucky bluegrass labeled without a variety name. Foreign material that is not common to grass seed shall not be added, other than material used for coating, as in subsection (C)(4), or combination products, as in subsection (C)(9).
f. Percentage by weight of all weed seeds. Weed seed content shall not exceed one-half of one percent by weight.
g. The sum total for subsections (a), (b), (c), (d), (e) and (f) shall equal 100 percent.
h. Noxious weeds that are required by this Article to be labeled shall be listed under the heading “noxious weed seeds.”
i. For each lawn and turf seed named under subsection (a) or (b):
   i. Percentage of germination, excluding hard seed;
   ii. Percentage of hard seed, if present;
   iii. Calendar month and year the germination test was completed to determine percentages in subsections (i) and (ii); and
   iv. For seed sold for retail non-farm usage the statement “sell by (month/year)” which shall be no more than 15 months from the date of the germination test excluding the month of the test.
j. Name and address of the labeler, or the person who sells, offers or exposes the seed for sale within this state.

4. For coated agricultural, vegetable, flower, or lawn and turf seeds that are sold by weight:
   a. Percentage by weight of pure seeds with coating material removed;
   b. Percentage by weight of coating material;
   c. Percentage by weight of inert material not including coating material;
   d. Percentage of germination determined on 400 pellets with or without seeds;
   e. All other applicable requirements in subsections (C)(1), (2), and (3).
5. For vegetable seeds in packets as prepared for use in home gardens or household plantings or vegetable seeds in pre-planted containers, mats, tapes, or other planting devices:
   a. Name of kind and variety of seed;
   b. Lot identification, such as by lot number or other means;
   c. One of the following:
      i. The calendar month and year the germination test was completed and the statement “Sell by (month/year).” The date indicated shall be no more than 12 months from the date of the test, excluding the month of the test;
      ii. The calendar year for which the seed was packaged for sale as “packed for (year)” and the statement “sell by (year)”; or
      iii. The percentage germination and the calendar month and year the test was completed to determine the percentage if the germination test was completed within 12 months, excluding the month of the test;
   d. Name and address of the labeler, or the person who sells, offers, or exposes the seed for sale within this state;
   e. For seeds that germinate less than the standard established under R3-4-404(A), (B) and (C)(i): percentage of germination, excluding hard seed; percentage of hard seed, if present; and the words “Below Standard” in not less than 8-point type;
   f. For seeds placed in a germination medium, mat, tape, or other device in such a way as to make it difficult to determine the quantity of seed without removing the seeds from the medium, mat, tape or device, a statement to indicate the minimum number of seeds in the container.
6. For vegetable seeds in containers other than packets prepared for use in home gardens, household plantings, preplanted containers, mats, tapes, or other planting devices:
   a. The name of each kind and variety present in excess of five percent and the percentage by weight of each in order of its predominance;
   b. Lot number or other lot identification;
   c. For each named vegetable seed:
      i. Percentage germination, excluding hard seed;
      ii. Percentage of hard seed, if present; and
      iii. The calendar month and year the test was completed to determine the percentages; The statement “Total germination and hard seed” may be included following the percentages required under subsections (C)(6)(c)(i) and (C)(6)(c)(ii);
   d. Name and address of the labeler, or the person who sells, offers or exposes the seed for sale within this state; and
   e. The labeling requirements for vegetable seeds in containers of more than one pound are met if the seed is weighed from a properly labeled container in the presence of the purchaser.
7. For agricultural seeds sold on a pure live seed basis, each container shall bear a label containing the information required by subsection (C)(2), except:
   a. The label need not show:
      i. The percentage by weight of each agricultural seed component as required by subsection (C)(2)(a); or
      ii. The percentage by weight of inert matter as required by subsection (C)(2)(g); and
   b. For each named agricultural seed, the label must show instead of the information required by subsection (C)(2)(h):
      i. The percentage of pure live seed; and
      ii. The calendar month and year in which the test determining the percentage of live seed was completed.

8. For agricultural and vegetable hybrid seeds that contain less than 95 percent hybrid seed:
   a. Kind or variety shall be labeled as "hybrid,"
   b. The percentage that is hybrid shall be labeled parenthetically in direct association following the named variety; for example – comet (85% hybrid), and
   c. Varieties in which the pure seed contains less than 75 percent hybrid seed shall not be labeled hybrids.
9. For combination mulch, seed, and fertilizer products:
   a. The word "combination" followed by the words "mulch – seed – fertilizer", as appropriate, shall appear on the upper 30 percent of the principal display panel. The word "combination" shall be the largest and most conspicuous type on the container, equal to or larger than the product name. The words "mulch – seed – fertilizer", as appropriate, shall be no smaller than one-half the size of the word "combination" and in close proximity to the word "combination."
   b. The products shall not contain less than 70 percent mulch.
   c. Agricultural, flower, vegetable, lawn, and turf seeds placed in a germination medium, mat, tape, or other device or mixed with mulch shall be labeled as follows:
      i. Product name;
      ii. Lot number;
      iii. Percentage by weight of pure seed of each kind and variety named. The kind and variety named may be less than 5 percent of the whole;
      iv. Percentage by weight of other crop seeds;
      v. Percentage by weight of inert matter, which shall not be less than 70 percent;
      vi. Percentage by weight of weed seeds;
      vii. The total of subsections (iii), (iv), (v), and (vi) shall equal 100 percent;
      viii. Name and number of noxious weed seeds per pound, if present;
      ix. Hard seed percentage, if present, and percentage of germination of each kind or kind and variety named and the month and year the test was completed; and
      x. Name and address of the labeler or the person who sells, offers or exposes the product for sale within this state.

D. Labeling requirements: flowers.
1. For flower seeds in packets prepared for use in home gardens or household plantings or flower seeds in preplanted containers, mats, tapes, or other planting devices:
   a. For all kinds of flower seeds:
      i. The name of the kind and variety or a statement of type and performance characteristics as prescribed in subsection (D)(3); and
      ii. Name and address of the labeler, or the person who sells, offers, or exposes the seed for sale within this state, and one of the following subsections (D)(1)(a)(iii) through (v);
      iii. The calendar month and year the germination test was completed and the statement "Sell by (month/year)." The date indicated shall be no more than 12 months from the date of the test excluding the month of the test; or
      iv. The calendar year for which the seed was packaged for sale as "packed for (year)" and the statement "sell by (year)"; or
      v. The percentage germination and the calendar month and year the test was completed to determine the percentage if the germination test was completed within 12 months, excluding the month of the test.
   b. For kinds of flower seeds for which standard testing procedures are prescribed by the Association of Official Seed Analysts and that germinate less than the germination standards prescribed under the provisions of R3-4-404(B):
      i. Percentage of germination, excluding hard seeds;
      ii. Percentage hard seed, if present; and
      iii. The words "Below Standard" in not less than eight-point type.
   c. For flower seeds placed in a germination medium, mat, tape, or other device in such a way as to make it difficult to determine the quantity of seed without removing the seeds from the medium, mat, tape, or device, a statement to indicate the minimum number of seeds in the container.
2. For flower seeds in containers other than packets and other than pre-planted containers, mats, tapes, or other planting devices and not prepared for use in home flower gardens or household plantings:
   a. The name of the kind and variety or a statement of type and performance characteristics as prescribed in subsection (D)(3), and for wildflowers, the genus and species and subspecies, if appropriate;
   b. The lot number or other lot identification;
   c. For wildflower seed with a pure seed percentage of less than 90 percent:
      i. The percentage, by weight, of each component listed in order of the component's predominance;
      ii. The percentage by weight of weed seed, if present; and
      iii. The percentage by weight of inert matter;
   d. For kinds of seed for which standard testing procedures are prescribed by the Association of Official Seed Analysts:
      i. Percentage of germination, excluding hard or dormant seed;
      ii. Percentage of hard or dormant seed, if present; and
      iii. The calendar month and year that the test was completed to determine the percentages in subsections (D)(2)(d)(i) and (ii);
   e. For those kinds of flower seed for which standard testing procedures are not prescribed by the Association of Official Seed Analysts, the year of production or collection; and
   f. Name and address of the labeler, or the person who sells, offers, or exposes the flower seed for sale within this state.
3. Requirements to label flower seeds with kind and variety, or type and performance characteristics as prescribed in subsection (D)(1)(a)(i) and (D)(2)(a) shall be met as follows:
   a. For seeds of plants grown primarily for their blooms:
      i. If the seeds are of a single named variety, the kind and variety shall be stated, for example, "Marigold, Butterball";
      ii. If the seeds are of a single type and color for which there is no specific variety name, the

type of plant, if significant, and the type and color of bloom shall be indicated, for example, "Scabiosa, Tall, Large Flowered, Double, Pink";

iii. If the seeds consist of an assortment or mixture of colors or varieties of a single kind, the kind name, the type of plant, if significant, and the type or types of bloom shall be indicated. It shall be clearly indicated that the seed is mixed or assorted. An example of labeling such a mixture or assortment is "Marigold, Dwarf Double French, Mixed Colors";

iv. If the seeds consist of an assortment or mixture of kinds or kinds and varieties, it shall clearly indicate that the seed is assorted or mixed and the specific use of the assortment or mixture shall be indicated, for example, "Cut Flower Mixture", or "Rock Garden Mixture". Statements such as "General Purpose Mixture", "Wonder Mixture", or any other statement that fails to indicate the specific use of the seed shall not be considered as meeting the requirements of this subsection unless the specific use of the mixture is also stated. Containers with over three grams of seed shall list the kind or kind and variety names of each component present in excess of five percent of the whole in the order of their predominance, giving the percentage by weight of each. Components equal to or less than five percent shall be listed, but need not be listed in order of predominance. A single percentage by weight shall be given for these components that are less than five percent of the whole. If no component of a mixture exceeds five percent of the whole, the statement, "No component in excess of 5%" may be used. Containers with three grams of seed or less shall list the components without giving percentage by weight and need not be in order of predominance.

b. For seeds of plants grown for ornamental purposes other than their blooms, the kind and variety shall be stated, or the kind shall be stated together with a descriptive statement concerning the ornamental part of the plant, for example, "Ornamental Gourds, Small Fruited, Mixed."

E. Label requirement for tree and shrub seeds. Tree or shrub seeds that is sold, offered for sale, or exposed for sale within this state shall bear on each container a plainly written or printed label or tag in English. No modifications or disclaimers shall be made to the required label information in the labeling or on another label attached to the container. Labeling of seed supplied under a contractual agreement meets this requirement if the shipment is accompanied by an invoice or by an analysis tag attached to the invoice if each bag or other container is clearly identified by a lot number permanently displayed on the container or if the seed is in bulk. Each bag or container not clearly identified by a lot number must carry complete labeling. The label shall include the following information:

1. For tree and shrub seeds that have been treated, the following may appear on a separate label:
   a. Language indicating that the seed has been treated;
   b. The commonly accepted chemical name of the applied substance or description of the process used;
   c. If the substance is harmful to human or animals, a caution statement such as "do not use for food or feed or oil purposes". The caution for highly toxic substances shall be a poison statement and symbol; and
   d. If the seed has been treated with an inoculant, the date of expiration, which is the date the inoculant is no longer considered effective;
2. For all tree and shrub seeds subject to this Article:
   a. Common name of the species of seed and if appropriate, the subspecies;
   b. The scientific name of the genus and species and if appropriate, the subspecies;
   c. Lot number or other lot identification;
   d. Origin.
      i. For seed collected from a predominantly indigenous stand, the area of collection given by latitude and longitude, a geographic description, or identification of a political subdivision, such as a state or county; or
      ii. For seed collected from other than a predominantly indigenous stand, identification of the area of collection and the origin of the stand, or the statement "origin not indigenous";
   e. The elevation or the upper and lower limits of elevations within which the seed was collected;
   f. Purity as a percentage of pure seed by weight;
   g. For those species listed under R3-4-404(C), the following apply except as provided in subsection (E)(2)(h):
      i. Percentage germination excluding hard seed;
      ii. Percentage of hard seed, if present;
      iii. The calendar month and year the test was completed to determine the percentages in subsection (a) and (b);
   h. Instead of complying with subsections (E)(2)(g)(i), (ii), and (iii), the seed may be labeled, "Test is in process, results will be supplied upon request";
   i. For those species for which standard germination testing procedures have not been prescribed, the calendar year in which the seed was collected; and
   j. Name and address of the labeler, or the person who sells, offers, or exposes the seed for sale within this state.

F. Hermetically sealed seed shall meet the following requirements

1. The seed shall have been packaged within nine months of harvest;
2. The container used shall not allow water vapor penetration through any wall, including the seals, greater than 0.05 grams of water per 24 hours per 100 square inches of surface at 100°F with a relative humidity on one side of 90 percent and on the other side 0 percent. Water vapor penetration (WVP) is measured in accordance with the U.S. Bureau of Standards as: gm H20/24 hr/100 sq in/ 100°F /90% RHV 0% RH;
3. The seed in the container shall not exceed the percentage of moisture, on a wet weight basis, as listed below:
   a. Agricultural Seeds,
      i. Beet, Field: 7.5;
      ii. Beet, Sugar: 7.5;
      iii. Bluegrass, Kentucky: 6.0;
      iv. Clover, Crimson: 8.0;
      v. Fescue, Red: 8.0;
      vi. Ryegrass, Annual: 8.0;
      vii. Ryegrass, Perennial: 8.0;

viii. All Others: 6.0; and
ix. Mixture of Above: 8.0;

b. Vegetable Seeds,
i. Bean, Garden: 7.0;
ii. Bean, Lima: 7.0;
iii. Beet: 7.5;
iv. Broccoli: 5.0;
v. Brussels Sprouts: 5.0;
vi. Cabbage: 5.0;
vii. Carrot: 7.0;
viii. Cauliflower: 5.0;
ix. Celeriac: 7.0;
x. Celery: 7.0;
xi. Chard, Swiss: 7.5;
xii. Chinese Cabbage: 5.0;
xiii. Chives: 6.5;
xiv. Collards: 5.0;
xv. Corn, Sweet: 8.0;
xvi. Cucumber: 6.0;
xvii. Eggplant: 6.0;
xviii. Kale: 5.0;
xix. Kohlrabi: 5.0;
xx. Leek: 6.5;
xxi. Lettuce: 5.5;
xxii. Muskmelon: 6.0;
xxiii. Mustard, India: 5.0;
xxiv. Onion: 6.5;
xxv. Onion, Welsh: 6.5;
xxvi. Parsley: 6.5;
xxvii.Parsnip: 6.0;
xxviii. Pea: 7.0;
xxix. Pepper: 4.5;
xxx. Pumpkin: 6.0;
xxxi. Radish: 5.0;
xxxii. Rutabaga: 5.0;
xxxiii. Spinach: 8.0;
xxxiv. Squash: 6.0;
xxxv. Tomato: 5.5;
xxxvi. Turnip: 5.0;
xxxvii. Watermelon: 6.5; and
xxxviii. All others: 6.0.

4. The container shall be conspicuously labeled in not less than 8-point type to indicate:
   a. That the container is hermetically sealed,
   b. That the seed has been preconditioned as to moisture content, and
   c. The calendar month and year in which the germination test was completed; and
5. The germination percentage of the seed at the time of packaging shall have been equal to or higher than the standards specified elsewhere in subsection R3-4-404.

Historical Note

Adopted effective December 21, 1981 (Supp. 81-6). Former Section R3-4-111 renumbered without change as Section R3-4-402 (Supp. 89-1). Section R3-4-402 renumbered from R3-1-402 (Supp. 91-4). Amended effective July 10, 1995 (Supp. 95-3). Amended by final rulemaking at 13 A.A.R. 1464, effective June 2, 2007 (Supp. 07-2).

R3-4-403. Noxious Weed Seeds

A. A person shall not allow the following prohibited noxious weed seeds in seed regulated under this Article:
1. *Acroptilon repens* (L.) DC. – Russian knapweed;
2. *Aegilops cylindrica* Host. – Jointed goatgrass;
3. *Alhagi maurorum* – Camelthorn;
4. *Alternanthera philoxeroides* (Mart.) Griseb. – Alligator weed;
5. *Cardaria pubescens* (C.A. Mey) Jarmolenko – Hairy whitetop;
6. *Cardaria chalepensis* (L.) Hand-Maz – Lens podded hoary cress;
7. *Cardaria draba* (L.) Desv. – Globed-podded hoary cress (Whitetop);
8. *Carduus acanthoides* L. – Plumeless thistle;
9. *Cenchrus echinatus* L. – Southern sandbur;
10. *Cenchrus incertus* M.A. Curtis – Field sandbur;
11. *Centaurea calcitrapa* L. – Purple starthistle;
12. *Centaurea iberica Trev. ex Spreng.* – Iberian starthistle;
13. *Centaurea squarrosa Willd.* – Squarrose knapweed;
14. *Centaurea sulphurea* L. – Sicilian starthistle;
15. *Centaurea solstitialis* L. – Yellow starthistle (St. Barnaby's thistle);
16. *Centaurea diffusa* L. – Diffuse knapweed;
17. *Centaurea maculosa* L. – Spotted knapweed;
18. *Chondrilla juncea* L. – Rush skeletonweed;
19. *Cirsium arvense* L. Scop. – Canada thistle;
20. *Convolvulus arvensis* L. – Field bindweed;
21. *Coronopus squamatus* (Forskal) Ascherson – Creeping wartcress (Coronopus);
22. *Cucumis melo* L. var. Dudaim Naudin – Dudaim melon (Queen Anne's melon);
23. *Cuscuta* spp. – Dodder;
24. *Cyperus rotundus* – Purple Nutgrass or Nutsedge;
25. *Cyperus esculentus* – Yellow Nutgrass or Nutsedge;
26. *Drymaria arenarioides* H.B.K. – Alfombrilla (Lightningweed);
27. *Eichhornia azurea* (SW) Kunth. – Anchored Waterhyacinth;
28. *Elymus repens* – Quackgrass;
29. *Euphorbia esula* L. – Leafy spurge;
30. *Halogeton glomeratus* (M. Bieb.) C.A. Mey – Halogeton;
31. *Helianthus ciliaris* DC. – Texas Blueweed;
32. *Hydrilla verticillata* (L.f.) Royle – Hydrilla (Florida-elodea);
33. Ipomoea spp. – Morning glory. All species except Ipomoea carnea, Mexican bush morning glory; Ipomoea triloba, three-lobed morning glory (which is considered a restricted pest); Ipomoea aborescens, morning glory tree; Ipomea batatas – sweetpotato; Ipomoea quamoclit, Cypress Vine; Ipomoea noctiflora, Moonflower – Morning Glories, Cardinal Climber, Hearts and Honey Vine;
34. *Isatis tinctoria* L. – Dyers woad;
35. *Linaria genistifolia* var. dalmatica – Dalmation toadflax;
36. *Lythrum salicaria* L. – Purple loosestrife;
37. *Medicago polymorpha* L. – Burclover;
38. *Nassella trichotoma* (Nees.) Hack. – Serrated tussock;
39. *Onopordum acanthium* L. – Scotch thistle;
40. *Orobanche ramosa* L. – Branched broomrape;
41. *Panicum repens* L. – Torpedo grass;
42. *Peganum harmala* L. – African rue (Syrian rue);
43. *Portulaca oleracea* L. – Common purslane;
44. *Rorippa austriaca* (Crantz.) Bess. – Austrian fieldcress;
45. *Salvinia molesta* – Giant Salvinia;
46. *Senecio jacobaea* L. – Tansy ragwort;
47. *Solanum carolinense* – Carolina horsenettle;
48. *Solanum elaegnifolium* – Silverleaf Nightshade;
49. *Sonchus arvensis* L. – Perennial sowthistle;
50. *Solanum viarum* Dunal – Tropical Soda Apple;
51. Sorghum species, perennial (*Sorghum halepense, Johnson grass, Sorghum almum*, and perennial sweet sudangrass);

52. *Stipa brachychaeta Godr.* – Puna grass;
53. *Striga* spp. – Witchweed;
54. *Trapa natans* L. – Water-chestnut;
55. *Tribulus terrestris* L. – Puncturevine.

B. A person shall not allow more than the number shown of the following restricted noxious weed seeds in a working sample of seed regulated by this Article; or, any more than 50 of any combination of the following restricted noxious weed seeds per working sample.

1. *Avena fatua* – Wild oat: 5;
2. *Brassica campestris* – Bird rape: 30;
3. *Brassica juncea* – Indian mustard: 30;
4. *Brassica niger* – Black mustard: 30;
5. *Brassica rapa* – Field mustard: 30;
6. *Cenchrus pauciflorus* – Sandbur: 10;
7. *Eichhornia crassipes (Mart.) Solms* – Floating waterhyacinth: 10;
8. *Euryops sunbcarnosus subsp. vulgaris* – Sweet resinbush: 10;
9. *Ipomoea triloba* L. – Three-lobed morning glory: 10;
10. *Rumex crispus* – Curly dock: 30;
11. *Salsola kali var. tenuifolia* – Russian thistle: 30;
12. *Sinapis arvensis* – Charlock or Wild mustard: 30; and
13. *Sida hederacea* – Alkali mallow: 30.

Historical Note

Adopted effective December 21, 1981 (Supp. 81-6). Former Section R3-4-112 renumbered without change as Section R3-4-403 (Supp. 89-1). Section R3-4-403 renumbered from R3-1-403 (Supp. 91-4). Section R3-4-403 repealed, new Section R3-4-403 renumbered from R3-4-405 and amended effective July 10, 1995 (Supp. 95-3). Amended by final rulemaking at 13 A.A.R. 1464, effective June 2, 2007 (Supp. 07-2).

R3-4-404. Germination Standards

A. Vegetable seed shall have the following minimum percent germination or the minimum percent germination as found in the Federal Seed Act, 20 CFR 201.31 (as amended January 1, 2002), which is incorporated by reference, not including future editions or amendments. The material is on file with the Department and available for purchase from the U. S. Government Bookstore (http://bookstore.gpo.gov/) or at the U.S. Government Printing Office, 732 N. Capitol St., NW, Washington, DC 20401 or it can be found online at http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=42bcf6d966081e2f2cf9d03315fb999f&rgn=div8&view=text&node=7:3.1.1.7.28.0.317.38&idno=7.

1. Artichoke: 60;
2. Asparagus: 70;
3 Asparagusbean: 75;
4. Bean, garden: 70;
5. Bean, Lima: 70;
6. Bean, runner: 75;
7. Beet: 65;
8. Broadbean: 75;
9. Broccoli: 75;
10. Brussels sprouts: 70;
11. Burdock, great: 60;
12. Cabbage: 75;
13. Cabbage, tronchuda: 70;
14. Cardoon: 60;
15. Carrot: 55;
16. Cauliflower: 75;
17. Celeriac: 55;
18. Celery: 55;
19. Chard, Swiss: 65;
20. Chicory: 65;
21. Chinese cabbage: 75;
22. Chives: 50;
23. Citron: 65;
24. Collards: 80;
25. Corn, sweet: 75;
26. Cornsalad: 70;
27. Cowpea: 75;
28. Cress, garden: 75;
29. Cress, upland: 60;
30. Cress, water: 40;
31. Cucumber: 80;
32. Dandelion: 60;
33. Dill: 60;
34. Eggplant: 60;
35. Endive: 70;
36. Kale: 75;
37. Kale, Chinese: 75;
38. Kale, Siberian: 75;
39. Kohlrabi: 75;
40. Leek: 60;
41. Lettuce: 80;
42. Melon: 75;
43. Mustard, India:75;
44. Mustard, spinach: 75;
45. Okra: 50;
46. Onion: 70;
47. Onion, Welsh: 70;
48. Pak-choi: 75;
49. Parsley: 60;
50. Parsnip: 60;
51. Pea: 80;
52. Pepper: 55;
53. Pumpkin: 75;
54. Radish: 75;
55. Rhubarb: 60;
56. Rutabaga: 75;
57. Sage: 60;
58. Salsify: 75;
59. Savory, summer: 55;
60. Sorrel: 65;
61. Soybean: 75;
62. Spinach: 60;
63. Spinach, New Zealand: 40;
64. Squash: 75;
65. Tomato: 75;
66. Tomato, husk: 50;
67. Turnip: 80;
68. Watermelon: 70; and
69. All Others: The germination standard for all other vegetable and herb seed for which a standard has not been established shall be 50 percent.

B. Flower seed shall meet the following minimum percent germination standards. For the kinds marked with an asterisk, the percentage listed is the sum total of the percentage germination and percentage of hard seed. A mixture of kinds does not meet the germination standard if the germination of any kind or combination of kinds constituting 25 percent or more of the mixture by number of seed is below the germination standard for the kind or kinds involved.

1. Archillea (The Pearl) – *Achillea ptarmica*: 50;
2. African Daisy – *Dimorphotheca aurantiaca*: 55;
3. African Violet – *Saintpaulia* spp: 30;
4. Ageratum – *Ageratum mexicanum*: 60;
5. Agrostemma (rose campion) – *Agrostemma coronaria*: 65;

6. Alyssum – *Alyssum compactum, A. maritimum, A. procumbens, A. saxatile*: 60;
7. Amaranthus – *Amaranthus* spp: 65;
8. Anagalis (primpernel) – *Anagalis arvensis, Anagalis coerulia, Anagalis grandiflora*: 60;
9. Anemone – *Anemone coronaria, A. pulsatilla*: 55;
10. Angel's Trumpet – *Datura arborea*: 60;
11. Arabis – *Arabis alpine*: 60;
12. Arctotis (African lilac daisy) – *Arctotis grandis*: 45;
13. Armeria – *Armeria formosa*: 55;
14. Asparagus, fern – *Asparagus plumosus*: 50;
15. Asparagus, sprenger, *Asparagus sprenger*: 55;
16. Aster, China – *Callistephus chinensis*; except Pompon, Powderpuff, and Princess types: 55;
17. Aster, China – *Callistephus chinensis*; Pompon, Powderpuff, and Princess types: 50;
18. Aubretia – *Aubretia deltoids*: 45;
19. Baby Smilax – *Aparagus asparagoides*: 25;
20. Balsam – *Impatiens balsamina*: 70;
21. Begonia – (*Begonia fibrous rooted*): 60;
22. Begonia – (*Begonia tuberous rooted*): 50;
23. Bells of Ireland – *Molucella laevis*: 60;
24. Brachycome (swan river daisy) – *Brachycome iberidifolia*: 60;
25. Browallia – *Browallia elata and B. speciosa*: 65;
26. Bupthalum (sunwheel) – *Buphthalum salicifolium*: 60;
27. Calceolaria – *Calceolaria* spp: 60;
28. Calendula – *Calendula officinalis*: 65;
29. California Poppy – *Eschscholtzia californica*: 60;
30. Calliopsis – *Coreopsis bicolor, C. drummondi, C. elegans*: 65;
31. Campanula:
    a. Canterbury Bells – *Campanula medium*: 60;
    b. Cup and Saucer Bellflower – *Campanula medium calycanthema*: 60;
    c. Carpathian Bellflower – *Campanula carpatica*: 50;
    d. Peach Bellflower – *Campanula persicifolia*: 50;
32. Candytuft, Annual – *Iberis amara, I. umbellate*: 65;
33. Candytuft, Perennial – *Iberis gibraltarica, I. sempervirens*: 55;
34. Castor Bean – *Ricinus communis*: 60;
35. Cathedral Bells – *Cobaea scandens*: 65;
36. *Celosia argentea*: 65;
37. Centaurea: Basket Flower – *Centaurea americana*, Cornflower – *C. cyanus*, Dusty Miller – *C. candidissima*, Royal Centaurea – *C. imperialis*, Sweet Sultan – *C. moschata*, Velvet Cantaurea – *C. gymnocarpa*: 60;
38. Snow-in-Summer *Cerastium biebersteini and C. tomentosum*: 65;
39. Chinese Forget-me-not – *Cynoglossum amabile*: 55;
40. Chrysanthemum, Annual – *Chrysanthemum carinatum, C. coronarium, C. Cineraria – Senecio cruentus*: 60;
41. Clarkia – *Clarkia elegans*: 65;
42. Cleome – *Cleome gigante*a: 65;
43. Coleus – *Coleus blumei*: 65;
44. Columbine – *Aquilegia* spp.: 50;
45. Coral Bells – *Heuchera sanguinea*: 55;
46. Coreopsis, Perennial – *Coreopsis lanceolata*: 40;
47. Corn, ornamental – *Zea mays*: 75;
48. Cosmos: Sensation, Mammoth and Crested types – *Cosmos bipinnatus*; Klondyke type – *C. sulphureau*: 65;
49. Crossandra – (*Crossandra infundibuliformis*): 50;
50. Dahlia – *Dahlia* spp: 55;
51. Daylily – *Hemerocallis* spp: 45;
52. Delphinium, Perennial – *Belladonna* and *Bellamosum* types; Cardinal Larkspur – *Delphinium cardinale*; *Chinensis types;* Pacific Giant, Gold Medal and other hybrids of *D. elatum*: 55;
53. Dianthus:
    a. Carnation – *Dianthus caryophyllus*: 60;
    b. China Pinks – *Dianthus chinensis, heddewigi, heddensis*: 70;
    c. Grass Pinks – *Dianthus plumarius*: 60;
    d. Maiden Pinks – *Dianthus deltoids*: 60;
    e. Sweet William – *Dianthus barbatus*: 70;
    f. Sweet Wivelsfield – *Dianthus allwoodi*: 60;
54. Didiscus – (blue lace flower) – *Didiscus coerulea*: 65;
55. Doronicum (leopard's bane) – *Doronicum caucasicum*: 60;
56. Dracaena – *Dracaena indivisa*: 55;
57. Dragon Tree – *Dracaena draco*: 40;
58. English Daisy – *Bellis perennis*: 55;
59. Flax – Golden flax *(Linum flavum);* Flowering flax L. *randiflorum;* Perennial flax, L. *perenne*: 60;
60. Flowering Maple – *Abutilon* spp: 35;
61. Foxglove – *Digitalis* spp: 60;
62. Gaillardia, Annual – *Gaillardia pulchella; G. picta*; Perennial – G. *grandiflora*: 45;
63. Gerbera (transvaal daisy) – *Gerbera jamesoni*: 60;
64. Geum – *Geum* spp: 55;
65. Gilia – *Gilia* spp: 65;
66. Glosiosa daisy (*rudbeckia*) – *Echinacea purpurea and Rudbeckia Hirta*: 60;
67. Gloxinia – (*Sinningia speciosa*): 40;
68. Godetia – *Godetia amoena, G. grandiflora*: 65;
69. Gourds: Yellow Flowered – *Cucurbita pepo*; White Flowered – *Lagenaria sisceraria*; Dishcloth – *Luffa cilíndrica*: 70;
70. Gypsophila: Annual Baby's Breath – Gypsophlla elegans; Perennial Baby's Breath – *G. paniculata, G. pacifica G. repens*: 70;
71. Helenium – *Helenium autumnale*: 40;
72. Helichrysum – *Helichrysum monstrosum*: 60;
73. Heliopsis – *Heliopsis scabra*: 55;
74. Heliotrope – *Heliotropium* spp: 35;
75. Helipterum (Acroclinium) – *Helipterum roseum*: 60;
76. Hesperis (sweet rocket) – *Hesperis matronalis*: 65;
77. *Hollyhock – *Althea rosea*: 65;
78. Hunnemania (mexican tulip poppy) – *Hunnemania fumariaefolia*: 60;
79. Hyacinh bean – *Dolichos lablab*: 70;
80. Impatiens – *Impatiens hostii*, *I. sultani*: 55;
81. **Ipomoea* – Cypress Vine – *Ipomoea quamoclit*; Moonflower – I. *noctiflora*; Morning Glories, Cardinal Climber, Hearts and Honey Vine – *Ipomoea* spp: 75;
82. Jerusulem cross (maltese cross) – *Lychnis chalcedonica*: 70;
83. Job's Tears – *Coix lacrymajobi*: 70;
84. Kochia – *Kochia childsi*: 55;
85. Larkspur, Annual – *Delphinium ajacis*: 60;
86. Lantana – *Lantana camara, L. hybrida*: 35;
87. Lilium (regal lily) – *Lilium regale*: 50;
88. Linaria – *Linaria* spp: 65, exception: *Linaria genistifolia* var. dalmatica – Dalmation toadflax which is a prohibited noxious weed;
89. Lobelia, Annual – *Lobelia erinus*: 65;
90. Lunaria, Annual – *Lunaria annua*: 65;
91. *Lupine – *Lupinus* spp: 65;
92. Marigold – *Tagetes* spp: 65;
93. Marvel of Peru – *Mirabilis jalapa*: 60;
94. Matricaria (feverfew) – *Matricaria* spp: 60;
95. Mignonette – *Reseda odorata*: 55;

96. Myosotis – *Myosotis alpestris, M. oblongata, M. palustres*: 50;
97. Nasturtium – *Tropaeolum* spp: 60;
98. Nemesia – *Nemesia* spp: 65;
99. Nemophila – *Nemophila insignis*: 70;
100. Nemophila, spotted – *Nemophila maculate*: 60;
101. Nicotiana – *Nicotiana affinis, N. sanderae, N. sylvestris*: 65;
102. Nierembergia – *Nierembergia* spp: 55;
103. Nigella – *Nigella damascena*: 55;
104. Pansy – *Viola tricolor*: 60;
105. Penstemon – *Penstemon barbatus, P. grandflorus, P. laevigatus, P. pubescens*: 60;
106. Petunia – *Petunia* spp: 45;
107. Phacelia – *Phacelia campanularia, P. minor, P. tanacetifolia*: 65;
108. Phox, Annual – *Phlox drummondi* all types and varieties: 55;
109. Physalis – *Physalis* spp: 60;
110. Platycodon (balloon flower) – *Platycodon grandiflorum*: 60;
111. Plumbago, cape – *Plumbago capensis*: 50;
112. Ponytail – *Beaucarnea recurvata*: 40;
113. Poppy: Shirley Poppy – *Papaver rhoeas;* Iceland Poppy – *P. nudicaule*; Oriental Poppy – *P. orientale*; Tulip Poppy – *P. glaucum*: 60;
114. Portulace – *Portulaca grandiflora*: 55;
115. Primula (primrose) – *Primula* spp: 50;
116. Pyrethrum (painted daisy) – *Pyrethrum coccineum*: 60;
117. Salpiglossis – *Salpiglossis gloxinaeflora, S. sinuata*: 60;
118. Salvia – Scarlet Sage – *Salvia splendens;* Mealycup Sage (Blue bedder) – *Salvia farinacea*: 50;
119. Saponaria – *Saponaria ocymoides, S. vaccaria*: 60;
120. Scabiosa, Annual – *Scabiosa atropurpurea*: 50;
121. Scabiosa, Perennial – *Scabiosa caucasica*: 40;
122. Schizanthus – *Schizanthus* spp: 60;
123. *Sensitive plant (mimosa) – *Mimosa pudica*: 65;
124. Shasta Daisy – *Chrysanthemum maximum C. leucanthemum*: 65;
125. Silk Oak – *Grevillea robusta*: 25;
126. Snapdragon – *Antirrhinum* spp: 55;
127. Solanum – *Solanum* spp: 60, exceptions; *Solanum carolinense* – Carolina horsenettle and *Solanum elaegnifolium* – Silverleaf Nightshade which are prohibited noxious weeds;
128. Statice – *Statice sinuata, S. suworonii* (flower heads): 50;
129. Stocks: Common – *Mathiola incana;* Evening Scented – *Mathiola bicornis*: 65;
130. Sunflower – *Helianthus* spp: 70, exception; *Helianthus ciliaris* DC. – Texas blueweed which is a prohibited noxious weed;
131. Sunrose – *Helianthemum* spp: 30;
132. *Sweet Pea, Annual and Perennial other than dwarf bush – *Lathyrus odoratus*, L. *latifolius*: 75;
133. *Sweet Pea, Dwarf Bush – *Lathyrus odoratus*: 65;
134. Tahoka Daisy – *Machaeanthera tanacetifolia*: 60;
135. Thunbergia – *Thunbergia alata*: 60;
136. Torcn Flower – *Tithonia speciosa*: 70;
137. Torenia (Wishbone Flower) – *Torenia fournieri*: 70;
138. *Tritoma kniphofia* Spp: 65;
139. Verbena, Annual – *Verbena hybrida*: 35;
140. Vinca – *Vinca rosea*: 60;
141. Viola – *Viola cornuta*: 55;
142. Virginian Stocks – *Malcolmia maritima*: 65;
143. Wallflower – *Cheiranthus allioni*: 65;
144. Yucca (Adam's Needle) – *Yucca filamentosa*: 50;
145. Zinnia (Except Linearis and Creeping) – *Zinnia angustifolia, Z. elegans, Z.grandiflora, Z. gracillima, Z. haegeana, Z. multiflora, Z. pumila*: 65;
146. Zinnia, Linearis and Creeping – *Zinnia linearis, Sanvitalia procumbens*: 50;
147. All Other Kinds: 50.

C. The germination labeling provisions of R3-4-402(E) apply to the following tree and shrub species:

1. *Abies amabilis* (Dougl.) Forbes – Pacific Silver Fir;
2. *Abies balsamea* (L.) Mill. – Balsam Fir;
3. *Abies concolor* (Gord. Glend.) Lindl. – White Fir;
4. *Abies fraseri* (Pursh.) Poir – Fraser Fir;
5. *Abies grandis* (Dougl.) Lindl. – Grand Fir;
6. *Abies homolepis* Sieb Zucc. – Nikko Fir;
7. *Abies lasiocarpa* (Hook) Nutt. – Subalpine Fir;
8. *Abies magnifica* A. Murr. – California Red Fir;
9. *Abies magnifica* var. *shastensis* Lemm. – Shasta Red Fir;
10. *Abies procera* Rehd. – Nobel Fir;
11. *Abies veitchii* (Lindl.) – Veitch Fir;
12. *Acer ginnala* Maxim. – Amur Maple;
13. *Acer macrophyllum* Pursh. – Bigleaf Maple;
14. *Acer negundo* L. – Boxelder;
15. *Acer pensylvanicum* L. – Striped Maple;
16. *Acer platanoides* L. – Norway Maple;
17. *Acer pseudoplatanus* L. – Sycamore Maple;
18. *Acer rubrum* L. – Red Maple;
19. *Acer saccharinum* L. – Silver Maple;
20. *Acer saccharum Marsh*, – Sugar Maple;
21. *Acer spicatum* Lam. – Mountain Maple;
22. *Aesculus pavia* L. – Red Buckeye;
23. *Ailanthus altissima* (Mill.) *Swingle* – Tree of Heaven, Ailanthus;
24. *Berberis thunbergil* DC. – Japanese Barberry;
25. *Berberis vulgaris* L. European Barberry;
26. *Betula lenta* L. – Sweet Birch;
27. *Betula alleghaniensis* Britton – Yellow Birch;
28. *Betula nigra* L. – River Birch;
29. *Betula papyrifera* Marsh. – Paper Birch;
30. *Betula pendula* Roth. – European White Birch;
31. *Betula populifolian* Marsh. – Gray Birch;
32. *Carya illinoensis* (Wang.) K. Koch – Pecan;
33. *Carya ovata* (Mill) K. Koch – Shagbark Hickory;
34. *Casuarina* spp. – Beefwood;
35. *Catalpa bignonioides* Walt. – Southern Catalpa;
36. *Catalpa speciosa* Warder. – Northern Caralpa;
37. *Cedrus atlantica* Manetti – Atlas Cedar;
38. *Cedrus deodara* (Roxb.) Loud. – Deodar Cedar;
39. *Cedrus libani* (Loud.) – Cedar of Lebanon;
40. *Clastrus scandens* L. – American Bittersweet;
41. *Celastrus orbiculata* Thunb. – Oriental Bittersweet;
42. *Chamaecyparis lawsoniana* (A. Murr.) Parl – Port Oxford Cedar;
43. C*hamaecyparis nootkatensis* (D. Don.) Spach. – Alaska Cedar;
44. *Cornus florida* L. – Flowering Dogwood;
45. *Cornus stolonifera* Michx. – Red-osier Dogwood;
46. *Crataegus mollis* – Downy Hawthorn;
47. *Cupressus arizonica* Greene – Arizona Cypress;
48. *Eucalyptus deglupta*;
49. *Eucalyptus gradis*;
50. *Fraxinus americana* L. – White Ash;
51. *Fraxinus excelsior* L. – European Ash;
52. *Fraxinus latifolia* Benth. – Oregon Ash;
53. *Fraxinus nigra* Marsh. – Black Ash;
54. *Fraxinus pensylvanica* Marsh. – Green Ash;

55. *Fraxinus pensylvanica* var. *lanceolata* (Borkh.) Sarg. – Green Ash;
56. *Gleditsia triacanthos* L. – Honey Locust;
57. *Grevillea robusta* – Silk-oak;
58. *Larix decidua* Mill, – European Larch;
59. *Larix eurolepis* Henry – Dunkfeld Larch;
60. *Larix leptolepis* (Sieb. Zucc.) Gord. – Japanese Larch;
61. *Larix occidentalis* Nutt. – Western Larch;
62. *Larix sibirica* Ledeb. – Siberian Larch;
63. *Libocedrus decurrens* – Incense-Cedar;
64. *Liquidambar styraciflua* L. – Sweetgum;
65. *Liriodendron tulipifera* L. – Yellow-Poplar;
66. *Magnolia grandiflora* – Southern Magnolia;
67. *Malus* spp. – Apple;
68. *Malus* spp. – Crabapple;
69. *Nyssa aquatica* L. – Water Tupelo;
70. *Nyssa sylvatica* var. sylvatica – Black Tupelo;
71. *Picea abies* (L.) Karst. – Norway Spruce;
72. *Picea engelmanni* Parry – Engelmann Spruce;
73. *Picea glauca* (Moench.) Voss – White Spruce;
74. *Picea glauca* var. albertiana (S. Brown) Sarg. – Western White Spruce, Alberta White Spruce;
75. *Picea glehnii* (Fr. Schmidt) Mast. – Sakhalin Spruce;
76. *Picea jezoensis* (Sieb. Zucc.) Carr – Yeddo Spruce;
77. *Picea koyamai* Shiras. – Koyama Spruce;
78. *Picea mariana* (Mill.) B.S.P. – Black Spruce;
79. *Picea omorika* (Pancic.) Purkyne – Serbian Spruce;
80. *Picea orientalis* (L.) Link. – Oriental Spruce;
81. *Picea polita* (Sieb. Zucc.) Carr – Tigertail Spruce;
82. *Picea pungens* Engelm. – Blue Spruce, Colorado Spruce;
83. *Picea pungens* var. *glauca* Reg. – Colorado Blue Spruce;
84. *Picea rubens* Sarg. – Red Spruce;
85. *Picea sitchensis* (Bong.) Carr – Sitka Spruce;
86. *Pinus albicaulis* Engelm. – Whitebark Pine;
87. *Pinus aristata* Engelm. – Bristlecone Pine;
88. *Pinus banksiana* Lamb. – Jack Pine;
89. *Pinus canariensis* C. Smith – Canary Pine;
90. *Pinus caribaea* – Caribbean Pine;
91. *Pinus cembroides* Zucc. – Mexican Pinyon Pine;
92. *Pinus clausa* – Sand Pine;
93. *Pinus conorta* Dougl. – Lodgepole Pine;
94. *Pinus contorta* var. *latifolia* Engelm. – Lodgepole Pine;
95. *Pinus coulteri* D. Don. – Coulter Pine, Bigcone Pine;
96. *Pinus densiflora* Sieb. Zucc. – Japanese Red Pine;
97. *Pinus echinata* Mill. – Shortleaf Pine;
98. *Pinus elliottii* Engelm. – Slash Pine;
99. *Pinus flexilis* James – Limber Pine;
100. *Pinus glabra* Walt. – Spruce Pine;
101. *Pinus griffithi* McClelland – Himalayan Pine;
102. *Pinus halepensis* Mill. – Aleppo Pine;
103. *Pinus jeffreyi* Grev. Balf. – Jeffrey Pine;
104. *Pinus khasya* Royle – Khasia Pine;
105. *Pinus lambertiana* Dougl. – Sugar Pine;
106. *Pinus heldreichii* var. *leucodermis* (Ant.) Markgraf ex Fitschen – Balkan Pine, Bosnian Pine;
107. *Pinus markusii* DeVriese – Markus Pine;
108. *Pinus monticola* Dougl. – Western White Pine;
109. *Pinus mugo* Turra. – Mountain Pine;
110. *Pinus mugo* var. *mughus* (Scop.) Zenari – Mugo Swiss Mountain Pine;
111. *Pinus muricata* D. Don. – Bishop pine;
112. *Pinus nigra* Arnold – Austrian Pine;
113. *Pinus nigra* poiretiana (Ant.) Aschers Graebn. – Corsican Pine;
114. *Pinus palustris* Mill. – Longleaf Pine;
115. *Pinus parviflora* Sieb. Zucc. – Japanese White Pine;
116. *Pinus patula* Schl. Cham. – Jelecote Pine;
117. *Pinus pinaster* Sol. – Cluster Pine;
118. *Pinus* pinea L. – Italian Stone Pine;
119. *Pinus ponderosa* Laws. – Ponderosa Plne, Western Yellow Pine;
120. *Pinus radiata* D. Don. – Monterey Pine;
121. *Pinus resinosa* Ait. – Red Pine, Norway Pine;
122. *Pinus rigida* Mill. – Pitch Pine;
123. *Pinus serotina* Michx. – Pond Pine;
124. *Pinus strobus* L. – Eastern White Pine;
125. *Pinus sylvestris* L. – Scots Pine;
126. *Pinus taeda* L. – Loblolly Pine;
127. *Pinus taiwanensis* Hayata – Formosa Pine;
128. *Pinus thunbergii* Parl. – Japanese Black Pine;
129. *Pinus virginiana* Mill. – Virginia Pine, Scrub Pine;
130. *Platanus occidentalis* L. – American Sycamore;
131. *Populus* spp. – Poplars;
132. *Prunus armeriaca* L. – Apricot;
133. *Prunus avium* L. – Cherry;
134. *Prunus domestica* L. – Plum, Prune;
135. *Prunus persica* Batsch. – Peach;
136. *Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco – Blue Douglas Fir;
137. *Pseudotsuga menziesii* var. *caesia* (Beissn.) Franco – Gray Douglas Fir;
138. *Pseudotsuga menziesii* var. *viridis* – Green Douglas Fir;
139. *Pyrus communis* L. – Pear;
140. *Quercus* spp. – (Red or Black Oak group);
141. *Quercus alba* L. – White Oak;
142. *Quercus muehlenbergii* Engelm. – Chinkapin Oak;
143. *Quercus virginiana* Mill. – Live Oak;
144. *Rhododendron* spp. – Rhododendron;
145. *Robinia pseudoacacia* L. – Black Locust;
146. *Rosa multiflora* Thunb. – Japanese Rose;
147. *Sequoia gigantea* (Lindl.) Decne. – Giant Sequoia;
148. *Sequoia sempervirens* (D. Don.) Engl. – Redwood;
149. *Syringa vulgaris* L. – Common Lilac;
150. *Thuja occidentalis* L. – Northern White Cedar, Eastern Arborvitae;
151. *Thuja orientalis* L. – Oriental Arborvitae, Chinese Arborvitae;
152. *Thuja plicata* Donn. – Western Red Cedar – Giant Arborvitae;
153. *Tsuga canadensis* (L.) Carr. – Eastern Hemlock, Canada Hemlock;
154. *Tsuga heterophylla* (Raf.) Sarg. – Western Hemlock, Pacific Hemlock;
155. *Ulmus americana* L. – American Elm;
156. *Ulmus parvifolia* Jacq. – Chinese Elm;
157. *Ulmus pumila* L. – Siberian Elm; and
158. *Vitis vulpina* L. – Riverbank Grape.

D. A person shall not indicate a quality of seed higher than the actual quality as found through germination test.

E. The labeler or the person who sells, offers, or exposes for sale within this state seeds in hermetically-sealed containers more than 36 months after the last day of the month in which the seeds were tested prior to packaging, shall retest the seeds within nine months, excluding of the calendar month in which the retest was completed, immediately prior to sale, exposure for sale, or offering for sale or transportation.

Historical Note

Adopted effective December 21, 1981 (Supp. 81-6). Former Section R3-4-113 renumbered without change as Section R3-4-404 (Supp. 89-1). Section R3-4-404 renumbered from R3-1-404 (Supp. 91-4). Section repealed, new Section R3-4-404 renumbered from R3-4-406 and amended effective July 10, 1995 (Supp. 95-3). Amended by final rulemaking at 13 A.A.R. 1464, effective June 2, 2007 (Supp. 07-2).

R3-4-405. Seed-certifying Agencies

A. Any agency seeking to obtain designation as a seed-certifying agency in Arizona shall meet the following requirements.
1. The agency shall be qualified by USDA to certify agricultural or vegetable planting seed as to variety, strain, and genetic purity.
2. The agency shall have a written seed certification protocol which includes standards, rules, and procedures for the certification of planting seed.
3. The agency shall have procedures for accepting crops and varieties into a certification program.
4. The agency shall be a member in good standing of a USDA-recognized association of official seed-certifying agencies such as the Association of Official Seed Certifying Agencies.

B. The Director or the Director's designee shall meet each calendar year with the director of the seed-certifying agency to review the agency's standards, rules, and procedures.

C. The Director may, after consulting with the Director of the Arizona Agricultural Experiment Station, revoke the agency's designation as the state seed-certifying agency after written 30 days' notice if the organization:
1. Fails to maintain qualifications, protocols, procedures, and membership as set forth in subsection (A); or
2. Fails to follow federal and state standards, rules, and procedures.

Historical Note

Adopted effective December 21, 1981 (Supp. 81-6). Former Section R3-4-114 renumbered without change as Section R3-4-405 (Supp. 89-1). Section R3-4-405 renumbered from R3-1-405 (Supp. 91-4). Section R3-4-405 renumbered to R3-4-403, new Section R3-4-405 renumbered from R3-4-407 and amended effective July 10, 1995 (Supp. 95-3).

R3-4-406. Sampling and Analyzing Seed

A. A person shall follow the methods of taking, handling, analyzing, and testing samples of seed and the tolerances and methods of determination as prescribed in the Federal Seed Act Regulations, 7 CFR 201.39 through 201.65, amended January 1, 2002, and in the Rules for Testing Seeds, 2006, published by the Association of Official Seed Analysts. This material is incorporated by reference and is on file with the Department. The materials incorporated by reference do not include any later amendments or editions. The Rules for Testing Seeds are also available through the web site: http://www.aosaseed.com. The CFR may be ordered from the Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA, 15250-7954 and the Rules for Testing Seeds may be ordered from the AOSA Management Office, Mail Boxes Etc. #285, 601 S. Washington, Stillwater, OK 74074-4539. If there is a conflict between the two documents, the requirements in CFR will prevail.

B. A labeler offering a seed for sale shall pay the cost of original germination and purity tests on each lot of seed offered for sale, and a dealer or labeler shall pay the cost of any subsequent germination test required by A.R.S. § 3-237. The Department shall pay the cost of testing seed samples drawn by a seed inspector from lots bearing valid labels. The dealer or labeler shall reimburse the Department for the cost of the test if the dealer or labeler chooses to use the Department's germination and purity results in subsequent re-labeling.

Historical Note

Adopted effective December 21, 1981 (Supp. 81-6). Former Section R3-4-115 renumbered without change as Section R3-4-406 (Supp. 89-1). Section R3-4-406 renumbered from R3-1-406 (Supp. 91-4). Section R3-4-406 renumbered to R3-4-404, new Section R3-4-406 renumbered from R3-4-408 and amended effective July 10, 1995 (Supp. 95-3). Amended by final rulemaking at 9 A.A.R. 1286, effective May 31, 2003 (Supp. 03-2). Amended by final rulemaking at 13 A.A.R. 1464, effective June 2, 2007 (Supp. 07-2).

R3-4-407. Phytosanitary Field Inspection; Fee

A. Applicants seeking phytosanitary certification for interstate and international exportation of agriculture, vegetable, and ornamental planting seed shall submit a $20.00 inspection fee and provide the following information on a form furnished by the Department:
1. The company name and address of the applicant;
2. The kind, variety, and lot number of the seed;
3. The number of acres on which the seed will be grown;
4. The name of the grower;
5. The county and field location;
6. The date of the application;
7. The countries of export;
8. The seed treatment, if applicable;
9. The amount of treatment, if applicable;
10. The approximate planting date;
11. The approximate harvest date; and
12. The export requirements.

B. The Department may contract with the state-certifying agency for field inspection at 20¢ per acre for any first or single required inspection and 10¢ per acre for each subsequent required inspection which shall be performed in conjunction with the seed certification program.

C. Field inspections conducted by the Department shall be based upon the following fee schedule and shall not exceed the maximum fee prescribed by A.R.S. § 3-233(A)(7):
1. Cotton: 80¢ per acre;
2. Small grain: 20¢ per acre for the first inspection and 80¢ for the second inspection;
3. Vegetable and all other crops: 20¢ for the first inspection and 80¢ for the second inspection.

D. If both the field inspection fee and the application fee exceeds the maximum fee per acre prescribed by A.R.S. § 3-233(A)(7), the application fee shall be voided and the maximum cost per acre shall be assessed.

Historical Note

Adopted effective December 21, 1981 (Supp. 81-6). Former Section R3-4-116 renumbered without change as Section R3-4-407 (Supp. 89-1). Section R3-4-407 renumbered from R3-1-407 (Supp. 91-4). Section R3-4-407 renumbered to R3-4-405, new Section adopted effective July 10, 1995 (Supp. 95-3).

R3-4-408. Licenses: Seed Dealer and Seed Labeler; Fees

A. An applicant for a seed dealer or seed labeler license shall provide the following to the Department:
1. The year for which the applicant wishes to be licensed;
2. The applicant's name, company name, telephone number, fax number and e-mail address, as applicable;
3. Verification of previous seed dealer or labeler license, if applicable;
4. The mailing and physical address of each business location being licensed;
5. Company Tax ID number or if not a legally-recognized business entity, the applicant's Social Security number;

6. The date of the application; and
7. The signature of the applicant.

B. Seed dealer and seed labeler licenses are not transferable, expire on June 30, and are valid for no more than one year, or period thereof, unless otherwise revoked, suspended, denied or otherwise acted upon by the Department as provided in A.R.S. § 3-233(A)(6).

C. An applicant shall submit a completed application to the Department accompanied by the following fee, which is non-refundable unless A.R.S. § 41-1077 applies.
1. Seed dealers, $50.00 per location; and
2. Seed labelers, $100.00.

D. During fiscal year 2011 and fiscal year 2012, notwithstanding subsection (C), there is no fee to obtain a seed dealer or seed labeler license.

Historical Note

Adopted effective December 21, 1981 (Supp. 81-6). Former Section R3-4-117 renumbered without change as Section R3-4-408 (Supp. 89-1). Section R3-4-408 renumbered from R3-1-408 (Supp. 91-4). Section R3-4-408 renumbered to R3-4-406, new Section adopted effective July 10, 1995 (Supp. 95-3). Amended by final rulemaking at 13 A.A.R. 1464, effective June 2, 2007 (Supp. 07-2). Amended by exempt rulemaking at 16 A.A.R. 2029, effective September 21, 2010 (Supp. 10-3). Amended by exempt rulemaking at 17 A.A.R. 1763, effective July 20, 2011 (Supp. 11-3).

R3-4-409. Violations and Penalties

A. The Department may assess the following penalties against a dealer or labeler for each customer affected by a violation listed below: $50 for the first offense, $150 for the second offense, and $300 for each subsequent offense within a three-year period:
1. Failure to complete the germination requirements on agricultural, vegetable, or flower seed intended for wholesale or commercial use within nine months prior to sale, exposing for sale, or offering for sale within the state, excluding the month in which the test was completed. This penalty does not apply to a violation under subsections (A)(2), or (3);
2. Failure to complete the germination requirements for agricultural, ornamental, or vegetable seed intended for retail purchase within the 15 months prior to the sale, exposing for sale, or offering for sale within the state, excluding the month in which the test was completed; and
3. Failure to obtain any license required by this Article;

B. The Department may assess the following penalties against any person committing the following acts: up to $500 for the first offense, up to $1250 for the second offense, and up to $2500 for each subsequent offense within a three-year period.
1. To label, advertise, or represent seed subject to this Article to be certified seed or any class of certified seed unless:
   a. It has been determined by a certifying agency that the seed conforms to standards of purity and identification as to kind, species and subspecies, if appropriate, or variety; and
   b. The seed bears an official label issued for the seed by a certifying agency certifying that the seed is of a specified class and a specified kind, species and subspecies, if appropriate, and variety;
2. To disseminate in any manner or by any means, any false or misleading advertisements concerning seeds subject to this Article;
3. To hinder or obstruct in any way, any authorized agent of the Department in the performance of the person's duties under this Article;
4. To fail to comply with a cease and desist order or to move or otherwise handle or dispose of any lot of seed held under a cease and desist order or tags attached to the order, except with express permission of the enforcing officer, and for a purpose specified by the officer;
5. To label or sell seed that has been treated without proper labeling;
6. To provide false information to any authorized person in the performance of the person's duties under this Article; or
7. To label or sell seed that has false or misleading labeling, including:
   a. Labeling or selling seed with a label containing the word "trace" or the phrase "contains 01%" as a substitute for any statement that is required by this Article;
   b. Altering or falsifying any seed label, seed test, laboratory report, record, or other document to create a misleading impression as to kind, variety, history, quality or origin of seed;
   c. Labeling as hermetically sealed containers of agricultural or vegetable seeds that have not had completed the germination requirements with 36 months prior to sale, excluding the month in which the test was completed;
   d. Failure to label in accordance with the provisions of this Article;
   e. If applicable, failing to label as containing prohibited noxious weed seeds, subject to recognized tolerances;
   f. If applicable, failing to label as containing restricted noxious weed seeds in excess of the number prescribed in R3-4-403 on the label attached to the container of the seed or associated with seed;
   g. If applicable, failing to label as containing more than two and one-half percent by weight of all weed seeds;
   h. Detaching, altering, defacing, or destroying any label provided for in this Article, or altering or substituting seed in a manner that may defeat the purpose of this Article;
   i. Using relabeling stickers without having both the calendar month and year the germination test was completed, the sell by date if appropriate, and the lot number that matches the existing, original lot number; and
   j. Selling, exposing for sale, or offering for sale within the state vegetable seed intended for retail purchase that has labeling containing germination information that has not been completed within the 12 months prior to selling, exposing for sale, or offering for sale.

Historical Note

New Section made by final rulemaking at 13 A.A.R. 1464, effective June 2, 2007 (Supp. 07-2).

ARTICLE 5. COLORED COTTON

R3-4-501. Colored Cotton Production and Processing

A. Definitions. In addition to the definitions provided in A.R.S. § 3-101 and R3-4-102, the following terms apply to this Section:
1. "Certified" means having been inspected with a written certificate of inspection issued by an inspector of the Department.

2. "Colored cotton" means any variety of cotton plants of the Genus *Gossypium* that produces fiber that is naturally any color other than white.
3. "Cottonseed" means processed seed cotton used for propagation, animal feed, crushed or composted fertilizer, or oil.
4. "Composting" means a process that creates conditions that facilitate the controlled decomposition of organic matter into a more stable and easily handled soil amendment or fertilizer, usually by piling, aerating and moistening; or the product of such a process.
5. "Delinting" means the process of using acid, flame, or mechanical means to remove fiber that remains on cottonseed after ginning.
6. "Planting seed" means seed of a known variety produced for planting subsequent generations.
7. "Seed cotton" means raw cotton containing seed and lint that has been harvested from a field, but has not been ginned.
8. "White cotton" means any variety of the Genus *Gossypium* that produces white fiber as established in 28 U.S.C. 401 through 451, the Official Cotton Standards of the United States for the Color Grade of American Upland Cotton, revised July 1, 1993; and Cotton Classification Results, revised July 1994. This material is incorporated by reference, does not include any later amendments or editions of the incorporated matter, and is on file with the Office of the Secretary of State.

B. Production requirements.
1. A producer who intends to grow colored cotton shall register in writing with the Department. The registration form shall be received at least 30 days before the cotton planting date for the applicable cultural cotton zone established in R3-4-204. Any colored cotton not registered with the Department shall be abated as established in A.R.S. §§ 3-204 and 3-205, and the producer may be assessed a civil penalty as established in A.R.S. § 205.02. The registration shall include:
   a. The name, address, telephone number, and signature of the producer;
   b. The name, address, telephone number, and signature of the property owner;
   c. The name, address, and telephone number of the organization or company contracting for the production of colored cotton or to whom the colored cotton will be sold, if known;
   d. The total number of acres to be planted;
   e. The geographical location of the proposed fields by county, section, township and range; and
   f. The name of the property owners, if known, adjacent to the field where colored cotton will be grown.
2. Separation of white and colored cotton.
   a. A colored cotton producer shall ensure that all colored cotton is planted no less than 500 feet from any white cotton field.
   b. All producers of white cotton saved for planting seed shall comply with the Field Standards in the Arizona Crop Improvement Association's Cotton Seed Certification Standards, revised July 1995. This material is incorporated by reference, does not include any later amendments or editions of the incorporated matter, and is on file with the Office of the Secretary of State.
3. A producer shall not plant white cotton on land on which colored cotton has been grown until one or more irrigated non-cotton crops have been produced on that land. If the non-cotton crop is not grown during a traditional cotton growing season, as established by R3-4-204(E), the field shall be irrigated before planting a white cotton crop.
4. The Department shall notify all cotton producers of the colored cotton plant-back restrictions and of the availability of location and acreage records of colored cotton crops.
5. The Department shall notify the Arizona Crop Improvement Association of the colored cotton geographical locations at least 25 days before the cotton planting date for each cultural cotton zone established in R3-4-204.

C. Cotton appliances.
1. No cotton producer, contractor, or ginner shall use a cotton appliance or gin to produce, transport, or handle white cotton after the gin or appliance has been used in the production, transportation, or handling of colored cotton until the Department inspects the cotton appliance or gin and finds it free of colored cottonseed, seed cotton, fiber, and gin trash. A cotton producer, contractor, or ginner shall notify the Department at least 48 hours, excluding Sundays and legal holidays, before an inspection is needed.
2. Colored seed cotton, cottonseed, fiber, and gin trash cleaned from cotton equipment, shall be composted or disposed of by the producer or ginner:
   a. On land where gin trash has previously been disposed and the land is managed as specified in subsection (B)(3); or
   b. In a landfill approved by the Department.
3. The Department shall legibly mark cotton appliances designated for exclusive use on colored cotton crops.

D. Transportation. Except in gin yards, colored cottonseed or colored seed cotton transported over public roads shall be totally enclosed or covered.

E. Gin requirements.
1. A gin owner or manager planning to process colored cotton shall notify the Department, in writing, no less than 30 days before processing the colored cotton.
2. The Department shall notify the Arizona Crop Improvement Association of a gin owner's or manager's intention to process colored cotton within 10 days from the receipt of the notification from the gin.
3. A gin owner or manager processing colored cotton shall not process white cotton until the gin has been cleaned, and inspected by the Department. The gin shall be free of cottonseed, seed cotton, and loose lint as established in subsection (C)(1).
4. If a gin processes colored seed cotton and white seed cotton during the same season, and the white cottonseed is not retained by the plant breeder for research purposes, the producer shall market the white cottonseed as:
   a. Animal feed,
   b. Crushed or composted fertilizer, or
   c. Oil.
5. The ginner shall legibly mark colored seed cotton kept in the gin yard or gin buildings and shall:
   a. Isolate the seed cotton at least 500 feet from white seed cotton, or
   b. Enclose it with two foot high chicken wire or chain link fencing.
6. Gin trash not disposed as established in subsection (C)(2) shall be shipped out-of-state, subject to the requirements of the receiving state and 7 CFR 301.52 et seq., amended August 30, 1994. This material is incorporated by reference, does not include any later amendments or editions

of the incorporated matter, and is on file with the Office of the Secretary of State.
7. The ginner shall bale or bag colored cotton fiber and mark the bale or bag as colored cotton.

F. Seed Requirements.
1. A producer or contracting organization, set forth in subsection (B)(1), saving colored cottonseed for propagative purposes shall legibly label the colored planting seed container and notify the Department of:
   a. The quantity,
   b. The variety or color,
   c. The location where the colored planting seed is held or stored, and
   d. Whether any seed will be shipped out-of-state.
2. If the cotton seed is being delinted in Arizona, the delinting facility shall follow the requirements in Harvesting, Handling and Tagging that are included in the Cotton Seed Certification Standards and have been incorporated by reference in subsection (B)(2)(b).
3. The producer shall render non-viable non-delinted (fuzzy) colored cottonseed not used for propagative purposes by crushing or composting. Whole or cracked colored cottonseed shall not be used as animal feed in Arizona but may be shipped out-of-state, subject to the requirements of the receiving state and 7 CFR 301.52 et seq.
4. Cotton producers shall not transport unbagged white cotton planting seed using vehicles or other equipment previously used to transport whole or cracked colored cottonseed until the Department has certified that these vehicles and equipment are free of colored cottonseed.

G. Advisory committee. The Director shall appoint an advisory committee, under A.R.S. § 3-106, to review colored cotton statutes and rules, inspection procedures, and certification methods. The committee shall be appointed for two-year staggered terms and a member may be reappointed for one additional term. The committee shall consist of one representative from each of the following categories:
1. The Cotton Research and Protection Council,
2. The Arizona Crop Improvement Association,
3. The Arizona Department of Agriculture,
4. The Arizona Cotton Growers Association,
5. A colored cotton producer,
6. A ginner ginning colored cotton, and
7. A contractor for the production of colored cotton.

Historical Note

Former Rule, Apiary Regulation 1. Amended effective June 19, 1978 (Supp. 78-3). Former Section R3-4-120 renumbered without change as Section R3-4-501 (Supp. 89-1). Former Section repealed, new Section adopted effective December 22, 1989 (Supp. 89-4). Section R3-4-501 renumbered from R3-1-501 (Supp. 91-4). Former Section R3-4-501 repealed, new Section R3-4-501 adopted effective October 15, 1993 (Supp. 93-4). R3-4-501 repealed by summary action with an interim effective date of February 10, 1995; filed in the Office of the Secretary of State January 20, 1995. Adopted summary rules filed in the Office of the Secretary of State May 17, 1995; interim effective date of February 10, 1995 now the permanent effective date (Supp. 96-3). New Section R3-4-501 renumbered from R3-4-205 and amended April 9, 1998 (Supp. 98-2).

R3-4-502. Repealed

Historical Note

Adopted effective December 22, 1989 (Supp. 89-4) Section R3-4-502 renumbered from R3-1-502 (Supp. 91-4). Former Section R3-4-502 repealed, new Section R3-4-502 adopted effective October 15, 1993 (Supp. 93-4). R3-4-502 repealed by summary action with an interim effective date of February 10, 1995; filed in the Office of the Secretary of State January 20, 1995. Adopted summary rules filed in the Office of the Secretary of State May 17, 1995; interim effective date of February 10, 1995, now the permanent effective date (Supp. 96-3).

R3-4-503. Repealed

Historical Note

Adopted as an emergency effective December 31, 1984, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 84-6). Emergency expired. Adopted as a permanent rule effective April 4, 1985 (Supp. 85-2). Former Sections R3-4-121.01, R3-4-121.02, R3-4-121.03, and R3-4-121.04 added to Section R3-4-121 and amended effective October 8, 1987 (Supp. 87-4). Former Section R3-4-121 renumbered without change as Section R3-4-502 (Supp. 89-1). Former Section R3-4-502 renumbered without change as Section R3-4-503 (Supp. 89-4). Repealed effective August 16, 1990 (Supp. 90-3). Section R3-4-503 renumbered from R3-1-503 (Supp. 91-4). New Section R3-4-503 adopted effective October 15, 1993 (Supp. 93-4). R3-4-503 repealed by summary action with an interim effective date of February 10, 1995; filed in the Office of the Secretary of State January 20, 1995. Adopted summary rules filed in the Office of the Secretary of State May 17, 1995; interim effective date of February 10, 1995, now the permanent effective date (Supp. 96-3).

R3-4-504. Repealed

Historical Note

Adopted as an emergency effective September 27, 1985, pursuant to A.R.S. § 41-1003, valid for only 90 days (Supp. 85-5). Emergency expired. Former Sections R3-4-122.01 through R3-4-122.03, emergency expired. New Section R3-4-122 adopted effective March 6, 1987 (Supp. 87-1). Former Section R3-4-122 renumbered without change as Section R3-4-503 (Supp. 89-1). Former Section R3-4-503 renumbered without change as Section R3-4-504 (Supp. 89-4). Section R3-4-504 renumbered from R3-1-504 (Supp. 91-4). Former Section R3-4-504 repealed, new Section R3-4-504 adopted effective October 15, 1993 (Supp. 93-4). R3-4-504 repealed by summary action with an interim effective date of February 10, 1995; filed in the Office of the Secretary of State January 20, 1995. Adopted summary rules filed in the Office of the Secretary of State May 17, 1995; interim effective date of February 10, 1995, now the permanent effective date (Supp. 96-3).

R3-4-505. Repealed

Historical Note

Adopted effective October 15, 1993 (Supp. 93-4). R3-4-505 repealed by summary action with an interim effective date of February 10, 1995; filed in the Office of the Secretary of State January 20, 1995. Adopted summary rules filed in the Office of the Secretary of State May 17, 1995; interim effective date of February 10, 1995, now the permanent effective date (Supp. 96-3).

R3-4-506. Repealed

Historical Note
Adopted effective October 15, 1993 (Supp. 93-4). R3-4-501 repealed by summary action with an interim effective date of February 10, 1995; filed in the Office of the Secretary of State January 20, 1995. Adopted summary rules filed in the Office of the Secretary of State May 17, 1995; interim effective date of February 10, 1995, now the permanent effective date (Supp. 96-3).

ARTICLE 6. RECODIFIED

Article 6, consisting of Sections R3-4-601 through R3-4-611 and Appendix A, recodified to 3 A.A.C. 3, Article 11 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-601. Recodified

Historical Note
Former Rule, Native Plant Regulation 1. Amended effective June 19, 1978 (Supp. 78-3). Amended by adding subsection (E) effective January 21, 1981 (Supp. 81-1). Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Former Section R3-4-130 renumbered without change as Section R3-4-601 (Supp. 89-1). Amended effective December 28, 1990 (Supp. 90-4). Section R3-4-601 renumbered from R3-1-601 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1101 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-602. Recodified

Historical Note
Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Former Section R3-4-131 renumbered without change as Section R3-4-602 (Supp. 89-1). Amended effective December 28, 1990 (Supp. 90-4). Section R3-4-602 renumbered from R3-1-602 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Section repealed; new Section adopted by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1102 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-603. Recodified

Historical Note
Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Amended effective May 15, 1984 (Supp. 84-3). Correction, amendment effective May 15, 1984 deleted samples of forms (Supp. 86-1). Former Section R3-4-132 renumbered without change as Section R3-4-603 (Supp. 89-1). Amended effective December 28, 1990 (Supp. 90-4). Section R3-4-603 renumbered from R3-1-603 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Section repealed; new Section R3-4-603 renumbered from R3-4-605 and amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1103 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-604. Recodified

Historical Note
Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Amended effective May 15, 1984 (Supp. 84-3). Former Section R3-4-133 renumbered without change as Section R3-4-604 (Supp. 89-1). Amended effective December 28, 1990 (Supp. 90-4). Section R3-4-604 renumbered from R3-1-604 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Section repealed; new Section adopted by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1104 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-605. Recodified

Historical Note
Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Former Section R3-4-134 renumbered without change as Section R3-4-605 (Supp. 89-1). Amended effective December 28, 1990 (Supp. 90-4). Section R3-4-605 renumbered from R3-1-605 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Former Section R3-4-605 renumbered to R3-4-603; new Section R3-4-605 adopted by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1105 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-606. Recodified

Historical Note
Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Former Section R3-4-135 renumbered without change as Section R3-4-606 (Supp. 89-1). Repealed effective December 28, 1990 (Supp. 90-4). Section R3-4-606 renumbered from R3-1-606 (Supp. 91-4). New Section adopted effective July 6, 1993 (Supp. 93-3). Amended effective December 20, 1994 (Supp. 94-4). Amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1106 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-607. Recodified

Historical Note
Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Former Section R3-4-137 renumbered without change as Section R3-4-608 (Supp. 89-1). Former Section R3-4-607 repealed, new Section R3-4-607 renumbered from R3-4-608 and amended effective December 28, 1990 (Supp. 90-4). Section R3-4-607 renumbered from R3-1-607 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Former Section R3-4-607 repealed; new Section R3-4-607 renumbered from R3-4-616 and amended at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1107 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-608. Recodified

Historical Note
Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982

(Supp. 82-2). Former Section R3-4-138 renumbered without change as Section R3-4-609 (Supp. 89-1). Former Section R3-4-608 renumbered to R3-4-607, new Section R3-4-608 adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-608 renumbered from R3-1-608 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Section repealed; new Section adopted at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1108 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-609. Recodified

Historical Note

Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Former Section R3-4-139 renumbered without change as Section R3-4-610 (Supp. 89-1). Former Section R3-4-609 repealed, new Section R3-4-609 renumbered from R3-4-610 and amended effective December 28, 1990 (Supp. 90-4). Section R3-4-609 renumbered from R3-1-609 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Section repealed; new Section adopted by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1109 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-610. Recodified

Historical Note

Former Section R3-4-130 amended and renumbered as R3-4-130 through R3-4-140 effective April 30, 1982 (Supp. 82-2). Former Section R3-4-140 renumbered without change as Section R3-4-611 (Supp. 89-1). Former Section R3-4-610 renumbered to R3-4-609, new Section R3-4-610 renumbered from R3-4-611 and amended effective December 28, 1990 (Supp. 90-4). Section R3-4-610 renumbered from R3-1-610 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Amended effective December 20, 1994 (Supp. 94-4). Section repealed; new Section adopted by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1110 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-611. Recodified

Historical Note

Renumbered to R3-4-610 effective December 28, 1990 (Supp. 90-4). Section R3-4-611 renumbered from R3-1-611 (Supp. 91-4). New Section adopted effective July 6, 1993 (Supp. 93-3). Former Section R3-4-611 repealed; new Section R3-4-611 renumbered from R3-4-618 and amended by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3). Section recodified to R3-3-1111 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

R3-4-612. Repealed

Historical Note

Adopted effective April 30, 1982 (Supp. 82-2). Former Section R3-4-141 renumbered without change as Section R3-4-612 (Supp. 89-1). Repealed effective December 28, 1990 (Supp. 90-4). Section R3-4-612 renumbered from R3-1-612 (Supp. 91-4). New Section adopted effective July 6, 1993 (Supp. 93-3). Section repealed by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3).

R3-4-613. Repealed

Historical Note

Adopted effective February 5, 1986 (Supp. 86-1). Former Section R3-4-144 repealed, new Section R3-4-615 adopted effective January 17, 1989 (see also R3-4-616) (Supp. 89-1). Repealed effective December 28, 1990 (Supp. 90-4). Section R3-4-615 renumbered from R3-1-615 (Supp. 91-4). New Section adopted effective July 6, 1993 (Supp. 93-3). Amended effective September 11, 1997 (Supp. 97-3). Section repealed by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3).

R3-4-614. Repealed

Historical Note

Adopted effective February 5, 1986 (Supp. 86-1). Former Section R3-4-144 repealed, new Section R3-4-615 adopted effective January 17, 1989 (see also R3-4-616) (Supp. 89-1). Repealed effective December 28, 1990 (Supp. 90-4). Section R3-4-615 renumbered from R3-1-615 (Supp. 91-4). New Section adopted effective July 6, 1993 (Supp. 93-3). Amended effective September 11, 1997 (Supp. 97-3). Section repealed by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3).

R3-4-615. Repealed

Historical Note

Adopted effective February 5, 1986 (Supp. 86-1). Former Section R3-4-144 repealed, new Section R3-4-615 adopted effective January 17, 1989 (see also R3-4-616) (Supp. 89-1). Repealed effective December 28, 1990 (Supp. 90-4). Section R3-4-615 renumbered from R3-1-615 (Supp. 91-4). New Section adopted effective July 6, 1993 (Supp. 93-3). Amended effective December 20, 1994 (Supp. 94-4). Section repealed by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3).

R3-4-616. Renumbered

Historical Note

Adopted effective February 5, 1986 (Supp. 86-1). Former Section R3-4-144 repealed, new Section R3-4-616 adopted effective January 17, 1989 (see also R3-4-615) (Supp. 89-1). Repealed effective December 28, 1990 (Supp. 90-4). Section R3-4-616 renumbered from R3-1-616 (Supp. 91-4). New Section adopted effective July 6, 1993 (Supp. 93-3). Amended effective December 20, 1994 (Supp. 94-4). Amended effective September 11, 1997 (Supp. 97-3). Section R3-4-616 renumbered to R3-4-607 by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3).

R3-4-617. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-617 renumbered from R3-1-617 (Supp. 91-4). Section R3-4-617 renumbered from R3-1-617 (Supp. 91-4). Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Section repealed by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3).

R3-4-618. Renumbered

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-618 renumbered from R3-1-618 (Supp. 91-4).

Section repealed, new Section adopted effective July 6, 1993 (Supp. 93-3). Section R3-4-618 renumbered to R3-4-611 by final rulemaking at 5 A.A.R. 2521, effective July 15, 1999 (Supp. 99-3).

R3-4-619. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-619 renumbered from R3-1-619 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-620. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-620 renumbered from R3-1-620 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-621. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-621 renumbered from R3-1-621 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-622. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-622 renumbered from R3-1-622 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-623. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-623 renumbered from R3-1-623 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-624. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-624 renumbered from R3-1-624 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-625. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-625 renumbered from R3-1-625 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-626. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-626 renumbered from R3-1-626 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-627. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-627 renumbered from R3-1-627 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-628. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-628 renumbered from R3-1-628 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-629. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-629 renumbered from R3-1-629 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-630. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-630 renumbered from R3-1-630 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-631. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-631 renumbered from R3-1-631 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-632. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-632 renumbered from R3-1-632 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

R3-4-633. Repealed

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-633 renumbered from R3-1-633 (Supp. 91-4). Section repealed effective July 6, 1993 (Supp. 93-3).

Appendix A. Recodified

Historical Note

Adopted effective December 28, 1990 (Supp. 90-4). Section R3-4-633, Appendix A renumbered from R3-1-633, Appendix A (Supp. 91-4). Appendix A repealed, New Appendix A adopted effective July 6, 1993 (Supp. 93-3). Amended effective December 20, 1994 (Supp. 94-4). Amended effective September 11, 1997 (Supp. 97-3). Appendix recodified to 3 A.A.C. 3, Article 11 at 10 A.A.R. 726, effective February 6, 2004 (Supp. 04-1).

ARTICLE 7. FRUIT AND VEGETABLE STANDARDIZATION

R3-4-701. Apple Standards

The standards for apples in Arizona are the standards prescribed for U.S. No. 1 apples in the United States Standards for Grades of Apples, 7 CFR 51.300 et seq, revised as of January 1, 2003. This material is incorporated by reference and on file with the Department. This incorporation by reference contains no future additions or amendments.

Historical Note

Section R3-4-701 renumbered from R3-7-101 (Supp. 91-4). Section repealed, new Section adopted effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 9 A.A.R. 4628, effective December 6, 2003 (Supp. 03-4).

R3-4-702. Apricot Standards

A. Definitions.
1. "Mature" means having reached the stage of maturity which will ensure the proper completion of the ripening process.
2. "Serious damage" includes any defect caused by limb rubs, growth cracks, dirt, scale, hail, disease, insects, mechanical injury, or any damage which causes breaking of the skin, or which affects the appearance or the edible or shipping quality of the apricot. Damage from well-

healed growth cracks more than 1/2 inch in length shall be considered as serious damage.

B. Apricots shall be of one variety which are mature but not soft, overripe, or shriveled and which are free from decay, worm holes, and from serious damage.

C. Not more than 5%, by count, of the apricots in any container or lot shall be allowed for any one defect and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Former Rule 100. Section R3-4-702 renumbered from R3-7-102 (Supp. 91-4). Section repealed, new Section adopted effective January 6, 1994 (Supp. 94-1).

R3-4-703. Asparagus Standards

A. Asparagus, when being packed or offered for sale, shall conform to the following standards:

1. Asparagus spears shall not be wilted or crushed;
2. Asparagus spears shall not be seriously damaged by spreading or seeded tips;
3. Asparagus spears shall not be seriously damaged by crooks unless the container clearly indicates it contains crooks;
4. Asparagus spears shall not have more than 2 inches of white on the butt, except that when bunched, 25% of the spears in any bunch may have up to 2 1/2 inches of white;
5. Asparagus spears shall be free from decay and serious damage;
6. Asparagus spears, when bunched, shall be uniform in size.

B. Not more than 5%, by count, of the spears in any lot shall be allowed for any one cause and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Former Rule 101. Section R3-4-703 renumbered from R3-7-103 (Supp. 91-4). Section repealed, new Section adopted effective January 6, 1994 (Supp. 94-1).

R3-4-704. Beets and Turnip Standards

A. Definition.

"Serious damage" means damage caused by decay, disease, scab, nematode, growth cracks, mechanical injury, stringiness, woodiness, being misshapen, or any condition which would cause a loss of 20% or more of the root during preparation for use.

B. Beets and turnips, when being packed or offered for sale, shall be free from serious damage.

C. Not more than 10% of the beets or turnips in any one lot shall fail to meet the requirements prescribed in this Section.

Historical Note

Former Rule 102; Amended paragraph (7) effective June 11, 1986 (Supp. 86-3). Section R3-4-704 renumbered from R3-7-104 (Supp. 91-4). Section repealed, new Section adopted effective January 6, 1994 (Supp. 94-1).

R3-4-705. Broccoli Standards

A. Definitions.

1. "Bunch" means stalks bound together to form a unit. A single stalk may be considered a bunch if it is approximately as large as bunches in the lot.
2. "Serious damage" means damage caused by means worm or insect injury, or any condition which would cause a loss of 20% or more, by volume, of any one stalk of broccoli.
3. "Stalk" means an individual unit of broccoli which consists of the stem, head cluster, and any attached leaves.

B. Broccoli, when being packed or offered for sale, shall be free from mold, decay, and serious damage.

C. Not more than 5%, by count, of a bunch of broccoli in any lot of containers or bulk lot shall be allowed for mold and decay and not more than 15%, by count, in any lot of containers or bulk lot shall fail to meet the total requirements prescribed in this Section.

Historical Note

Former Rule 103. Section R3-4-705 renumbered from R3-7-105 (Supp. 91-4). Former Section R3-4-705 renumbered to R3-4-736, new Section R3-4-705 adopted effective January 6, 1994 (Supp. 94-1).

R3-4-706. Brussels Sprouts Standards

A. Definitions.

1. "Discoloration" means the appearance is materially affected by discolored leaves or parts of discolored leaves.
2. "Fairly firm" means the Brussels sprouts are not soft or spongy.
3. "Fairly well colored" means that the Brussels sprouts shall not be lighter than yellowish green color.
4. "Insects" means that:
   a. There is serious damage by aphid infestation within the compact portion of the head; or
   b. The outer leaves are seriously damaged by infestation; or
   c. Slug worms or worm frass are present; or
   d. The appearance is materially affected by slug or worm damage.
5. "Seedstems" means the seedstem is showing or the formation of the seedstalk has plainly begun.
6. "Serious damage" includes damage caused by discoloration, dirt or other foreign materials, freezing, disease, insects, mechanical injury.

B. Brussels sprouts shall be fairly well colored, fairly firm, not withered or burst, and free from soft decay, seedstems, and serious damage.

C. To allow for variations incident to proper grading and handling, not more than 5%, by weight, of the Brussels sprouts in any lot shall be allowed for any one defect and not more than 10%, by weight, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Former Rule 104. Section R3-4-706 renumbered from R3-7-106 (Supp. 91-4). Former Section R3-4-706 renumbered to R3-4-737, new Section R3-4-706 adopted effective January 6, 1994 (Supp. 94-1).

R3-4-707. Cabbage Standards

A. Definition.

"Serious damage" means damage caused by seedstems, discoloration, freezing, disease, insects, mechanical injury, or any condition which would cause a loss of 20% or more, by weight, of the head leaves.

B. Cabbage, when being packed or offered for sale, shall be firm, not withered, puffy, or burst, and shall be free from soft rot and decay and from serious damage.

C. Not more than 5%, by count, of the heads in any lot of containers or bulk lot shall be allowed for soft rot or decay and not more than 15%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Former Rule 105; Amended effective March 5, 1982 (Supp. 82-2). Section R3-4-707 renumbered from R3-7-107 (Supp. 91-4). Former Section R3-4-707 repealed, new Section R3-4-707 adopted effective January 6, 1994 (Supp. 94-1).

R3-4-708. Cantaloupe Standards; Maturity Sampling; Packing Arrangements

A. Definitions.
1. "Mature" means that a cantaloupe has reached the stage of development that ensures the completion of the normal ripening process, the arils that surround the seed during development of maturity are absorbed, and the juice of the edible portion contains not less than nine percent soluble solids as determined by the standard hand refractometer.
2. "Serious damage" means damage caused by bruises, sunburn, growth cracks, cuts, sponginess, flabbiness, or wilting.

B. Cantaloupes shall be:
1. Mature but not overripe;
2. Fairly well-netted;
3. Free from mold, decay, and insect damage that penetrates or damages the edible portion of the cantaloupe; and
4. Free from serious damage.

C. If a preliminary inspection of cantaloupes as prescribed at R3-4-738(A) indicates that further testing for maturity is required, the inspector shall randomly select melons for testing and average the results to determine the percent of soluble solids for each lot. The minimum number of cantaloupes selected from a lot for maturity sampling is as follows:

Melons Per Container	Min. Melons Per Container Tested
9 or less	7
12	8
15	11
18	13
22	15
23	16
24 or more	2/3 of the melons, not to exceed 30 melons

D. The Department shall not permit more than five percent, by count, of the cantaloupes in any one lot for any one defect and not more than 10 percent, by count, to fail the total requirements prescribed in this Section.

E. All cantaloupes in each container shall be of one variety or of similar varietal characteristics.

F. Cantaloupes packed in containers shall be uniform in size and packed in a compact arrangement.

Historical Note

Former Section R3-4-708 renumbered to R3-4-740, new Section R3-4-708 adopted effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 5 A.A.R. 569, effective February 3, 1999 (Supp. 99-1). Amended by final rulemaking at 8 A.A.R. 4454, effective October 2, 2002 (Supp. 02-4). Amended by final rulemaking at 10 A.A.R. 677, effective February 3, 2004 (Supp. 04-1).

R3-4-709. Carrot Standards

A. Definition.
"Serious damage" means damage caused by growth cracks, mechanical injury, being misshapen, or any condition which would cause a loss of 20% or more of the root during preparation for use.

B. Carrots, when being packed or offered for sale, shall be free from decay and insect injury which has penetrated or damaged the flesh and shall be free from serious damage. Not more than 10% of any lot of carrots shall fail to meet these requirements.

C. When bunched, carrots shall be uniform in size. When carrots range in diameter from 3/4 inch to 1 1/4 inches, a bunch shall contain 8 to 11 carrots, and if over 1 1/4 inches, five to seven carrots.

D. Topped carrots when packed in lugs, boxes, crates, or sacks shall be uniform in size.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-710. Cauliflower Standards

A. Definition.
"Serious damage" means damage caused by worm, insect injury, freezing, sunburn, or any other condition which would cause a loss of 20% or more of the edible portion of an individual head of cauliflower.

B. Cauliflower, when being packed or offered for sale, shall be free from mold, decay, and serious damage.

C. Cauliflower shall be trimmed to the number of leaves necessary to protect the head.

D. Not more than 5%, by count, of heads of cauliflower in any lot of containers or bulk lot shall be allowed for mold and decay and not more than 15%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-711. Celery Standards

A. Definitions.
1. "Pithy branches" means the stalk has more than four branches which are pithy; provided that not more than 10%, by count, of the stalks in any one lot or container are pithy.
2. "Seedstems" means that the stalk has a seedstem the length of which is more than twice the diameter of the stalk measured at a point 2 inches above the point of attachment at the root.
3. "Serious damage" includes damage caused by freezing, growth cracks, dirt, insect damage, seedstems, pithy branches, decay, black-heart, mechanical injury.

B. Celery, when being packed or offered for sale, shall be fairly well developed, free from serious damage.

C. The number of stalks in each container shall be specified by numerical count, or in terms of dozens or half-dozens, in block numerals not less than 1/2 inch in height on the container. A three-stalk variation from the specified count shall be allowed.

D. Not more than 5%, by count, of the celery in any container or lot shall be allowed for any one defect and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-712. Cherry Standards

A. Definitions.
1. "Clean" means that the cherries are practically free from dirt, dust, spray residue, or other foreign material.
2. "Fairly well colored" means that the cherries show the characteristic color of mature cherries of the variety.
3. "Mature" means that the cherries have reached a stage of growth which will ensure the proper completion of the ripening process.

4. "Serious damage" includes damage caused by bruises, cracks, disease, hail, other insects, limb rub, pulled stems, russeting, scars, skin breaks, sunburn, sutures, mechanical injury.
5. "Similar varietal characteristics" means that the cherries in any container are similar in color and shape.
6. "Well-formed" means that the cherry has normal shape characteristic of the variety.

B. Cherries shall be of similar varietal characteristics which are mature but are not soft, overripe, or shriveled, and which are fairly well colored, well-formed, clean, and free from decay, worms or worm holes, undeveloped doubles, sun scald, and free from serious damage.

C. Not more than 5%, by count, of the cherries in any one lot shall be allowed for any one defect and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-713. Corn Standards

A. Definition.
"Serious damage" means wilting, shriveling, worms, disease, decay, insects, or any condition which would cause a loss of 10% or more to an individual ear of corn.

B. Corn, when being packed or offered for sale, shall be mature but not over-mature, as indicated by a "doughy" condition of the kernels, and shall be free from serious damage.

C. Not more than 10%, by count, of the ears in any lot shall fail to meet the requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-714. Endive, Escarole, or Chicory Standards

A. Definitions.
1. "Fairly well blanched" means that the plant shall have a yellowish white to white heart formation with a spread averaging not less than four inches in diameter when the head is opened as far as possible without breaking the leaves or leaf stems.
2. "Serious damage" includes damage caused by seedstems; broken, bruised, spotted or discolored leaves; wilting; dirt; disease; insects; mechanical injury.
3. "Similar varietal characteristics" means that the plants shall be of the same type, such as curly-leaved endive or broad-leaved escarole.
4. "Well trimmed" means that the root shall be neatly cut close to the point of attachment of the outer leaf stems.

B. Endive, escarole, or chicory shall consist of plants of similar varietal characteristics, which are fresh, well trimmed, fairly well blanched, free from decay and from serious damage.

C. In order to allow for variations incident to proper grading and handling, not more than 5%, by count, shall be allowed for decay; not more than 10%, by count, shall be allowed for any other cause; and not more than 15%, by count, shall fail to meet the total requirements prescribed in this Section;

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-715. Greens Standards (Collards, Rapini, Mustard, and Turnip)

A. Definitions.
1. "Fairly clean" means that the appearance of the greens is not materially affected by the presence of mud, dirt, or other foreign materials.
2. "Fairly tender" means that the greens are not old, tough, or excessively fibrous.
3. "Fresh" means that the leaves are not more than slightly wilted.
4. "Serious damage" includes damage caused by discoloration, freezing, foreign material, seedstems, disease, insects, mechanical injury.

B. Greens shall be of one variety, which are fresh, fairly tender, fairly clean, and which are free from decay and free from serious damage.

C. Not more than 5%, by weight, of the greens in any container or lot shall be allowed for any one defect and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

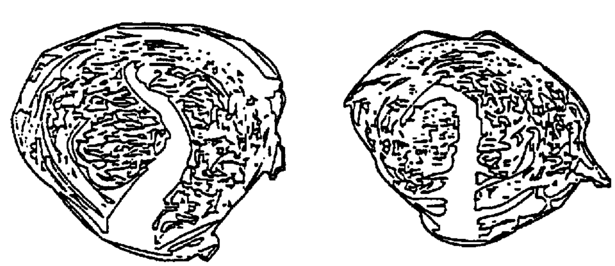
Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-716. Head Lettuce Standards

A. Definition.
"Serious damage" means damage caused by broken midribs, bursting, freezing, or tipburn:
1. "Broken midribs" is considered serious damage when the midribs of more than four of the outer head leaves are broken and severed all the way across the midrib.
2. "Bursting" is considered serious damage when the head is cracked or split open and any part of the inner portion of the head is exposed.
3. "Freezing" is considered serious damage when it affects any portion of the head inside the six outer head leaves, and the tissue of the inner head leaves is brittle, soft, pithy, or discolored due to freezing.
4. "Tipburn" is considered serious damage when the affected portion on one or more leaves, inside the six outer head leaves, exceeds an aggregate area of 1 inch by 1/2 inch and the color of the tipburn is light buff or darker. Serious damage does not include areas showing tan or brown specks with normal lettuce color between the specks.

B. Head lettuce, when being packed or offered for sale, shall:
1. Be mature;
2. Be free from serious damage.
3. Not be leafy without head formation;
4. Have no more than six wrapper leaves adhering to the head;
5. Be free from insect injury, slime, or decay affecting the leaves within the head;
6. Be free from a seedstem present upon internal examination that is less than 1/2 inch from the top of the head of lettuce or exceeds 4 inches in length.

LETTUCE SEEDSTEM



C. Not more than 5%, by count, of the heads of lettuce in any one lot of containers or bulk lot shall contain decay or slime and not more than 15%, by count, shall fail to meet all requirements prescribed in this Section.

D. Individual containers in any lot shall not contain more than 1 1/2 times the tolerance of defects prescribed in this Section provided the average percentage of defects in the entire lot is within the tolerances specified in subsection (C), as determined by inspection of a representative sample under R3-4-738.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 6 A.A.R. 4582, effective November 13, 2000 (Supp. 00-4).

R3-4-717. Melon Standards (Persian Melons, Casabas, Crenshaw, Honeydew, Honeyball, Other Specialty Melons, and Watermelons); Maturity Sampling

A. Definitions.
1. "Mature" means that:
   a. A melon has reached the stage of development that ensures proper completion of the normal ripening process and the arils that surround the seed during development of maturity are absorbed;
   b. The juice of the edible portion of honeyball and honeydew melons contains not less than 10 percent soluble solids as determined by the standard hand refractometer; and
   c. The flesh of a watermelon, except for yellow flesh watermelon, shall be colored to a degree not less than that indicated by Hue 4, Chrome H, in Plate 1, of A, Maerz and M. Rea Paul Dictionary of Color, first edition, published 1930. This material is incorporated by reference and is on file with the Department. This incorporation by reference contains no future editions or amendments.
2. "Serious damage" means damage to a melon caused by:
   a. Growth cracks, cuts, bruises, or softness;
   b. Beetle damage when it affects an area of more than 10 percent of the total surface of a watermelon;
   c. Whiteheart if apparent on internal examination;
   d. Sunburn when the sunburned area, regardless of size, is devoid of green coloration and is turning brown; or
   e. Rindrot when the distinct brown color or decay in the edible flesh of at least one inch in aggregate occurs in the edible portion of a watermelon.

B. All melons, except watermelons, when packed or offered for sale, shall be:
1. Mature but not overripe;
2. Free from mold, decay, and insect damage that penetrates or damages the edible portion of the melon; and
3. Free from serious damage.

C. Watermelons, when packed or offered for sale, shall be:
1. Fairly well-shaped;
2. Mature but not overripe;
3. Free from mold, decay, insect and beetle damage; and
4. Free from serious damage.

D. If a preliminary inspection of honeydew or honeyball melons as prescribed at R3-4-738(A) indicates that further testing for maturity is required, the inspector shall randomly select melons for testing and average the results to determine the percent of soluble solids for each lot:
1. When sampling honeydew or honeyball melons for maturity in lot containers that are not bulk containers, the minimum number of melons to be sampled is as follows:

Containers in Lot	Melons Sampled
Up to 400	7
401 to 600	9
Over 600	Add 3 melons for every additional 500 containers or fraction of 500 additional containers

2. When sampling honeydew or honeyball melons for maturity in bulk containers, seven honeydew or honeyball melons shall be selected at random from the top of the bulk container. The minimum number of bulk containers to be sampled is as follows:

No. of Bulk Containers	Containers Sampled
Less than 10	2
10 to 30	3
31 to 50	4
51 or more	5

E. The Department shall not permit more than five percent, by count, of the melons in any one lot for any one defect and not more than 10 percent, by count, to fail the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 5 A.A.R. 569, effective February 3, 1999 (Supp. 99-1). Amended by final rulemaking at 10 A.A.R. 677, effective February 3, 2004 (Supp. 04-1).

R3-4-718. Nectarine Standards

A. Definitions.
1. "Growth cracks" means cracks more than 5/8 inch in length, whether healed or not healed.
2. "Heat injury, sprayburn, or sunburn" means the skin is blistered, cracked, or decidedly flattened or badly discolored.
3. "Scab or bacterial spot" means the aggregate area exceeds that of a circle 3/4 inch in diameter.
4. "Serious damage" includes damage caused by bruises, growth cracks, hail, heat injury, sunburn, sprayburn, scab, bacterial spot, scale, split pit, scars, russeting, other diseases, insects, mechanical injury.
5. "Split pit." When causing an unhealed crack or when affecting the shape to the extent that the fruit is badly misshapen.
6. "Scars." When dark or rough scars in the aggregate area exceed that of a circle 3/4 inch in diameter.
7. "Russeting" means that 10% of the fruit surface is rough or slightly rough.

B. Nectarines shall be of one variety, which are mature but not overripe; not badly misshapen; clean; free from decay, broken skins which are not healed, worms and worm holes; and free from serious damage.

C. Not more than 5%, by count, of the nectarines in any container or lot shall be allowed for any one defect and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-719. Okra Standards

A. Definition.
"Serious damage" means damage caused by disease, decay, insects, woodiness, stringiness, or any condition which would cause a loss of 10% or more to an individual pod.

B. Okra, when being packed or offered for sale, shall be free from serious damage.

C. Not more than 10% of the pods in a lot shall fail to meet the requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-720. Dry Onion Standards

A. Definitions.
1. "Mature" means that the onion is fairly well cured and at least fairly firm.
2. "Serious damage" means damage caused by:
   a. Insect injury that has penetrated or affected the appearance or the edible portion of the onion;
   b. Mold and decay;
   c. Wet or dry sunscald, when affecting 1/3 of the total surface area;
   d. Seedstems, when more than 1/2 inch in diameter;
   e. Sprouting, when any visible sprout is more then 1 inch in length;
   f. Staining, dirt, or other foreign material, when the onions in any lot are affected in appearance of 25% or more of the total surface;
   g. Mechanical injury, when cuts seriously damage the appearance or edible portion of the onion;
3. "Similar varietal characteristics" means that the onions in any container are similar in color, shape, and character of growth.

B. Dry onions shall be of similar varietal characteristics, mature, and free from serious damage.

C. Not more than 5%, by weight, of the onions in any lot shall be allowed decay or wet sunscald and not more than 20%, by weight, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-721. Pea Standards

A. Definition.
"Serious damage" includes damage caused by disease, mold, decay, freezing, dirt, insects, or from mechanical injury.

B. Peas, when being packed fresh or sold shall be mature but not over-mature and shall be fairly well filled, fresh, firm, and free from serious damage.

C. Not more than 10%, by weight, of any lot shall fail to meet the requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-722. Peach Standards

A. Definitions.
1. "Badly misshapen" means that the shape of the fruit deviates from the shape characteristics of the variety or is otherwise deformed to the extent that it affects its appearance.
2. "Mature" means that the peach has reached a stage of growth, which will ensure a proper completion of the ripening process.
3. "Serious damage" includes damage caused by cuts which are not healed, worms, worm holes, bruises, dirt, or other foreign material, bacterial spots, scab, scale, growth cracks, hail damage, leaf or limb rubs, split pits, other disease, insects, mechanical injury.

B. Peaches shall be of one variety, which are mature but are not soft or overripe, not badly misshapen, and which are free from decay and free from serious damage.

C. Not more than 5%, by count, of the peaches in any container or lot shall be allowed for any one defect and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-723. Pear Standards

A. Definitions.
1. "Serious damage" includes damage caused by internal breakdown, scald, freezing damage, worm holes, black end, hard end, broken skins, bruises, russeting limb rubs, hail, scars, drought spots, sunburn, sprayburn, stings or other insect damage, disease, mechanical injury.
2. "Seriously misshapen" means that the pear is excessively flattened or elongated for the variety.

B. Pears shall be of one variety, which are mature but not overripe, clean, not seriously misshapen, free from decay, and free from serious damage.

C. Not more than 5%, by count, of the pears in any container or lot shall be allowed for any one defect and not more then 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-724. Sweet Pepper Standards

A. Definitions.
1. "Firm" means that the pepper is not soft, shriveled, limp, or pliable, although it may yield to slight pressure.
2. "Mature green" means that the pepper has reached the stage of development that withstands normal handling and shipping.
3. "Not seriously misshapen" means that the pepper is not badly indented, crooked, constricted, or otherwise badly deformed.
4. "Serious damage" means damage caused by freezing injury, hail, scars, sunburn, disease, insects, mechanical injury, or any one of the following defects or combination of defects, the seriousness of which exceeds the maximum for any one defect:
   a. Sunscald;
   b. Any opening or puncture through the fleshy wall of the pepper;
   c. Scars means evidence of scarring scattered over an aggregate surface area exceeding a circle 1 inch in diameter, or one scar 3/4 inch in diameter on a pepper 2 1/2 inches in length and 2 1/2 inches in diameter;
   d. Sunburn means discoloration which affects an aggregate area exceeding 25% of the surface of the pepper;
   e. Bacterial spot means evidence of bacteria over an aggregate area exceeding a circle 1 inch in diameter on a pepper 2 1/2 inches in length and 2 1/2 inches in diameter.

5. "Similar varietal characteristics" means each pepper shall be of the same general type. Thin- and thick-walled types shall not be mixed.

B. Sweet peppers, when being packed or offered for sale, shall be of the same varietal characteristics which are mature green, firm, not seriously misshapen, free from sunscald and decay, and free from serious damage.

C. Any lot of peppers which meets all the requirements prescribed in this Section, except those relating to color, shall be designated as "Red" if at least 90% of the peppers show any amount of a shade or red color; or as "Mixed Color" if the peppers fail to meet the requirements of "Green" or "Red."

D. Not more than 5%, by count, of the peppers in any container or lot shall be allowed for sunscald; not more than 2%, by count, shall be allowed for decay; and not more than 10%, by count, shall fail to meet the total requirements in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-725. Fresh Plum and Prune Standards

A. Definitions:
1. "Badly misshapen" means that shape of the fruit deviates from the shape characteristics of the variety or is otherwise so malformed or rough that it affects its appearance. Doubles shall be considered badly misshapen.
2. "Serious damage" includes damage caused by broken skins, heat damage, growth cracks, sunburn split pits, hail marks, drought spots, gum spots, russeting scars, other disease, insects, mechanical injury.

B. Fresh plums or prunes shall be of one variety which are not badly misshapen, which are clean, mature but not overripe or soft or shriveled, which are free from decay or sunscald, and free from serious damage.

C. Not more than 5%, by count, of the fruit in any one container or lot shall be allowed for any one defect and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-726. Potato Standards

A. Definitions.
1. "Badly skinned" means that more than 50% of the skin of the individual potato is missing or feathered.
2. "Serious damage" means damage caused by dirt or other foreign matter, sunburn, greening, second growth, growth cracks, air cracks, hollow heart, internal discoloration, shriveling, scab, dry rot, rhizoctonia, insect, larvae, worms, other diseases, mechanical injury, or any external defect which cannot be removed without a loss of more than 10% of the total weight of the potato.
3. "Seriously misshapen" means that the potato is pointed, dumbbell-shaped, or otherwise deformed.

B. All potatoes when being packed or sold shall conform to the following standards:
1. Potatoes shall be of the same varietal characteristics and shall not be seriously misshapen or frozen;
2. Unless otherwise specified, the diameter of each potato shall be not less than 1 1/2 inches and not more than an average of 3% of the potatoes in any one container or lot. Not more than 6% of the potatoes in any one container or lot shall fail to meet such specified minimum size requirements, except that potatoes sold or offered for sale as U.S. No. 1 shall have a diameter of not less than 1 7/8 inches, unless otherwise specified on the container thereof;
3. Potatoes shall be free from black heart, late blight, southern bacterial wilt, ringrot, softrot, or wet breakdown;
4. Potatoes shall be free from serious damage.

C. Not more than 30% of the potatoes in any one container or lot may be badly skinned.

D. Not more than a total of 12%, by weight, of the potatoes in any one container or bulk lot shall fail to meet the standards prekscribed in this Section; provided that the following percentages shall be allowed for the following defects:
1. Not more than 6% for potatoes having external defects;
2. Not more than 6% for potatoes which are seriously damaged by hollow heart, internal discoloration, or other internal defects; provided that not more than 3% of the external and internal defects shall be allowed for potatoes which are frozen or affected by southern bacterial wilt, ringrot, or late blight;
3. Not more than 3% shall be allowed for potatoes affected by soft rot or wet breakdown;

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-727. Romaine Standards

A. Definitions.
1. "Serious damage" includes damage caused by decay; seedstems; broken, bruised, or discolored leaves; tipburn; wilting; foreign material; freezing; dirt; insects; mechanical injury.
2. "Well developed" means that the plant shows normal growth and shape.
3. "Well trimmed" means that the stem is trimmed close to the point of the outer leaves.

B. Romaine, when being packed or offered for sale, shall consist of plants of the same varietal characteristics which are fresh, well developed, well trimmed, and free from serious damage.

C. Seedstems shall be considered as serious damage when the length of the attached seedstem is more than 1/2 the overall plant length, or when any portion of the seedstem has been removed.

D. Not more than 5% of the plants in any one container or lot shall be allowed for decay and not more than 10% shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-728. Spinach Standards

A. Definition.
"Serious damage" means damage caused by insects, disease, tip burn, frost injury, or any condition which would cause a loss of 20% or more of the leaves during preparation for use.

B. Spinach, when being packed or offered for sale, shall be free from serious damage.

C. Not more than 5% of the spinach in any one lot shall be allowed for decay and not more than 10% shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-729. Strawberry Standards

A. Definitions.
1. "Mature" means any strawberry which has not less than 2/3 of the surface showing a characteristic reddish color.
2. "Serious damage" includes damage caused by rain, irrigation, sun, bruising, disease, insects.

B. Strawberries shall be mature but not overripe and not noticeably undeveloped or deformed; shall have the cap (calyx) attached, and shall be free from cuts, molds, decay, and serious damage.

C. Strawberries, when being packed or offered for sale, shall be contained in the dry pint basket containing an interior capacity of approximately 33 6/10 cubic inches.

D. Not more than 5%, by count, of the berries in any one container or subcontainer shall be allowed for any one cause and not more than 10%, by count, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-730. String Bean Standards

A. Definition.

"Serious damage" means damage caused by freezing, hail, dirt, disease or insect injury, rust, anthracnose, mold, mildew, decay or from mechanical injury, or any condition to an individual pod which would cause a loss of 10% or more to any one bean.

B. String beans, when being packed or offered for sale, shall be mature, free-snapping but not overmature, and shall be free from serious damage.

C. Not more than 10% of the beans in a lot shall fail to meet the requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-731. Summer Squash Standards

A. Definition.

"Serious damage" includes damage caused by freezing, discoloration, cuts, bruises, scars, dirt or other foreign material, disease, insects, mechanical damage.

B. Summer squash shall consist of one variety or similar varietal characteristics which are not old and tough but are firm, free from decay and breakdown, and free from serious damage.

C. Not more than 5%, by weight, of the squash in any container or lot shall be allowed for decay or breakdown and not more than 10%, by weight, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-732. Sweet Potato Standards

A. Definition.

"Serious damage" means damage caused by insect injury, bruises, growth cracks, freezing, grass roots, or any condition which would cause a waste of 10%, by weight, to a potato.

B. Sweet potatoes shall be free from mold, decay, soft and wet rot, and free from serious damage.

C. When packed in lugs, boxes of sacks, sweet potatoes shall be fairly uniform in size.

D. Not more than 5%, by weight, of sweet potatoes in a container or bulk lot shall be allowed for decay and not more than 20%, by weight, shall fail to meet the total requirements prescribed in this Section.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-733. Table Grape Standards

A. Definitions.

1. "Mature" shall be applied when the following conditions exist in each bunch of grapes tested:
   a. The juice of all varieties contains soluble solids equal to, or in excess of, 18 parts to every part of acid contained in the juice (the acidity of the juice to be calculated as tartaric acid without water of crystallization);
   b. Perlettes; at least 15% soluble solids;
   c. Black Beauty Seedless; at least 15% soluble solids;
   d. Thompson Seedless and Flame Seedless varieties; at least 16% soluble solids;
   e. Exotic variety; at least 14% soluble solids.
2. "Serious damage" means more than 5%, by count, of the berries on any one bunch are affected by one or more of the defects set forth in subsection (A)(3).
3. "Serious defects" means:
   a. "Decay" means any soft breakdown of the flesh or skin of the berry resulting from bacterial or fungus infection. Slight surface development of green mold (cladosporium) shall not be considered decay.
   b. "Mildew and insect damage" includes the penetration or damage of the flesh of the berry, mold, decay, raisined berries, sunburned or dried berries, water or red berries, mechanical injury.
   c. "Raisined berries" means berries which are fully cured resembling raisins and which do not contain sufficient juice to drop from the berry under ordinary pressure between the thumb and finger.
   d. "Red berry" means a condition closely resembling waterberry. Such grapes show a red or brownish red color in addition to the general characteristics of waterberry.
   e. "Sunburned or dried berries" means grapes which show complete drying out, from any cause, of part or all of any individual berries.
   f. "Waterberry" means a condition characterized by a watery, soft, or flabby condition of the berries. Such affected berries are low in sugar content, have tender skins, and are very easily crushed.
   g. "Wet" means that the grapes are wet from moisture due to crushed, leaking, or decayed berries or from rain. Grapes which are moist from dew or other moisture condensation such as that resulting from removing grapes from a refrigerator car or cold storage to a warmer location shall not be considered as wet.

B. Table grapes shall consist of bunches of grapes which are mature and free from serious damage due to serious defects.

C. Not more than 10%, by weight, of the bunches in any one container or bulk lot shall fail to meet the requirements prescribed in this Section.

D. In all varieties, the testing of soluble solids in the juice shall be determined by the hand refractometer.

E. The maturity of varieties, prescribed in subsection (A)(1), shall be determined by testing the juice of entire bunches after removing the bunches from a standard 22-pound container; or 10%, by weight, of the least mature grapes in appearance from a contiguous area in the container in any other container.

F. No lot of grapes shall be considered as failing to meet the maturity requirements if the sample of grapes from one container fails to meet the required percent of soluble solids for that variety.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-734. Tomato Standards

A. Definition.

"Serious damage" means damage caused by blossom end rot, mosaic, alkali spot, sunscald, bruises, catfaces, blossom end scars, and growth cracks.

B. Tomatoes shall be mature but not overripe and shall be free from insect injury which has penetrated or materially damaged the flesh, wet or soft rot, blight, freezing injury, and from serious damage.
C. Tomatoes when being packed or sold shall be virtually uniform in size.
D. Not more than 5% of tomatoes in any container or lot shall be allowed for any one cause and not more than 10% shall fail to meet the total requirements prescribed in this Section.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-735. Winter Squash Standards
A. Definition.
"Serious damage" means damage caused by soft rot or wet breakdown, freezing, dirt, diseases, insects, mechanical damage, and also includes:
1. Scars caused by rodents or other means, which are not well healed or corked over, or which cover more than 25% of the surface of the squash in the aggregate area;
2. Dry rot which affects an area of more than 2 inches in diameter in the aggregate area on a 10-pound squash or an equivalent amount on a smaller or larger squash.

B. Winter squash shall be of similar varietal characteristics which are fairly well mature, not broken or cracked, and are free from serious damage.
C. Not more than 5%, by weight, of a squash in any lot shall be allowed for soft rot or wet breakdown and not more than 10%, by weight, shall fail to meet the total requirements prescribed in this Section.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-736. Standards for Unlisted Fresh Fruits and Vegetables, Experimental Product Standards
A. The following standards shall apply for those fresh fruit and vegetables for which specific quality standards are not otherwise established in this Article.
B. At least 90% by weight or by count of all fresh fruit or vegetables packed or offered for sale shall be free from insect injury which has penetrated or damaged the edible portion of the product and shall be free from worms, mold, decay, or other serious defects which damage the appearance or the shipping quality of the commodity as determined by an inspection of a representative sample prescribed in R3-4-738.
C. All experimental products shall be subject to the standards for unlisted fresh fruit and vegetables prescribed in this Section and the requirements for labeling containers prescribed in R3-4-737.

Historical Note
Section R3-4-736 renumbered from R3-7-705 and amended effective January 6, 1994 (Supp. 94-1).

R3-4-737. Container Labeling for Fruit and Vegetables
A. All containers shall bear in plain sight and plain letters on one outside panel the following:
1. Shipper or customer identification:
    a. The name of the shipper; and
    b. The city, state, and zip code of the shipper; or
    c. The name, address, and logo of the customer; and
    d. The shipper's identifying code.
2. The common or generic name of the commodity in each container; and
3. The count, measure, or net weight of the commodity contained in each container, except for bulk containers.

B. A container shall not bear any false or misleading statement.
C. If a shipper or customer reuses a container bearing the name of a different shipper or customer, the shipper or customer shall remove or obliterate all markings or labels from the container before commercial reuse.
D. Fruit and vegetables for processing.
1. If a pallet or container is clearly market "FOR PROCESSING ONLY," the information in subsection (A) is not required if the pallet or container is used to transport fruit or vegetables to a processing plant.
2. Fruit or vegetables transported to a processing plant may be packed on a pallet or in a container bearing a label for a commodity other than the commodity within the container.

Historical Note
Section R3-4-737 renumbered from R3-7-706 and amended effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 5 A.A.R. 569, effective February 3, 1999 (Supp. 99-1). Amended by final rulemaking at 6 A.A.R. 143, effective December 8, 1999 (Supp. 99-4).

R3-4-738. Inspection and Representative Sampling for Fruit and Vegetables
A. An inspector shall conduct a preliminary inspection of each commodity which includes a visual and physical inspection of specimens of the commodity. When determining compliance of a field packing operation, the inspector shall select specimens from widely separated areas of the packing operation. When determining compliance in a packing shed, warehouse, fruit stand, retail store, or other business which sells fruit or vegetables, containers shall be selected at random from widely separated parts of the lot. If one-half of the containers or specimens in the containers of the lot or field packing operation comply with the requirements of this Article and the other half of the containers or specimens in the containers of the lot or field packing operation do not, an equal number of containers or specimens in the containers shall be examined from each half.
B. If, after the preliminary inspection, the inspector determines that the quality of the product meets or exceeds the requirements of this Article, the inspector need not complete a comprehensive inspection. If, after the preliminary inspection, there is a failure to comply with the requirements of this Article, the inspector shall conduct a comprehensive inspection.
C. For a comprehensive inspection of a field packing operation, all specimens in each container of the official sample shall be examined by an inspector. For a comprehensive inspection of a wholesale warehouse, fruit stand, retail store, or any other business dealing with the sale of fruit or vegetables, an inspector may examine all specimens in each container of the official sample. The official sample of the lot shall consist of an inspection of no less than two containers for the first 100 containers of the lot and one container for every 100 containers thereafter. For example:

No. of Containers	Containers Sampled
2-100	2
101-200	3
201-300	4
301-400	5
401-500	6

D. In a comprehensive inspection of a wholesale warehouse, fruit stand, retail store, or any other business dealing with the sale of fruit or vegetables, an inspector need only examine a portion of the specimens in each container of the official sample. The official sample of the lot shall consist of an inspection of no less than the following:

No. of Containers	Containers Sampled

less than 10	2
10-30	3
31-50	4
51-100	5
101-200	6
201-300	8
301-500	10

E. If only a portion of the specimens in each container of the official sample is examined during a comprehensive inspection in lots in excess of 500 containers, the official sample shall consist of the number of containers equal to at least 1/2 the square root of the total number of containers in the lot. For example:

No. of Containers	Containers Sampled
501-600	12
601-700	13
701-800	14
801-900	15
901-1000	16

F. Except for apples and head lettuce, individual containers in any lot may contain up to double the amount of serious damage and other requirements prescribed for that commodity as long as the percentage of all requirements in the entire lot averages within the percent allowable as determined by inspection of a representative sample.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-739. Reconditioning for Fruit and Vegetables

A. Any lot or part of a lot in a grower and shipper packing facility which is found to be in violation of Article 7 of these rules shall be reconditioned within 72 hours. If the lot or part of the lot is not brought into compliance within the established time limit, an inspector shall proceed with the provisions prescribed in A.R.S. § 3-486.

B. Any lot or part of a lot in a wholesale warehouse, fruit stand, retail store, or any other business dealing in the sale of fruit and vegetables which is found to be in violation of Article 7 of these rules shall be reconditioned within 48 hours. If the lot or part of the lot is not brought into compliance within the established time limit, an inspector shall proceed with the provisions, as prescribed in A.R.S. § 3-486.

C. The supervisor or the supervisor's designee may grant a time extension for reconditioning the lot or part of the lot if the owner or holder of the lot or part of the lot which fails to comply with this Article requests an extension in writing with a specific date and time the lot or part of the lot will be reconditioned. The written request for the time extension for reconditioning may be delivered to the supervisor or the supervisor's designee in person, by mail or by facsimile. If the lot or part of the lot is not brought into compliance with this Article within the established time limit, an inspector shall proceed with the provisions prescribed in A.R.S. § 3-486.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-740. Experimental Pack and Product Permits for Fruit and Vegetables

A. An applicant for a permit for the use of an "experimental pack" or "experimental product," under A.R.S. § 3-487(B)(3), shall provide the following information on a form furnished by the Department:
1. The applicant's name, company name, address, and telephone number;
2. The name and description of the product packed in the container;
3. The description of the arrangement of the product packed in the container; and
4. The period for use of the experimental pack or product.

B. The shipper or packer shall make the experimental product conform to the standards for unlisted fresh fruit and vegetables prescribed in R3-4-736.

C. Upon completion of permit requirements by the applicant, the supervisor shall grant a permit that is valid for one year from the date of issuance.

D. An applicant may request renewal of an experimental pack or product permit. The Department shall not grant a renewal permit for the same experimental pack or product for more than three consecutive years, unless the rulemaking process prescribed under A.R.S. § 3-497, to standardize the experimental pack or product is initiated.

Historical Note

Section R3-4-740 renumbered from R3-4-708 and amended effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 8 A.A.R. 4454, effective October 2, 2002 (Supp. 02-4).

R3-4-741. Inspection Fee

A. Pursuant to A.R.S. § 3-489, any unlicensed person requesting inspection of citrus, fruit, vegetables, or nuts shall be charged travel expenses and an hourly fee of $30.00, as prescribed in A.R.S. § 38-621 et seq.

B. All fees are non-refundable and shall be paid to the Citrus, Fruit and Vegetable Revolving Fund upon completion of the inspection, as prescribed in A.R.S. § 3-489(B).

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-742. Recordkeeping and Reporting Requirements for Fruit and Vegetable Commission Merchants

A. Every commission merchant shall keep a correct record of each consignment of farm products received for sale, showing:
1. The name and address of the consignor;
2. The date of the consignment received;
3. The condition and quantity of produce upon arrival;
4. The date of the sale;
5. The price for which sold;
6. An itemized statement of charges to be paid by the consignor;
7. The names and addresses of purchasers if the commission merchant has a financial interest in the business of the purchasers, or if the purchasers have a financial interest in the business of the commission merchant, either directly or indirectly, as holder of the other's corporate stock, as partner, as lender or borrower of money to or from the other, or otherwise;
8. The lot number or other identifying mark of each consignment, which shall appear on all records necessary to show what the produce actually sold for;
9. All claims filed by the commission merchant against any person for overcharges or for damages resulting from the injury of the person.

B. The commission merchant shall retain the original or a copy of records covering each sale or transaction with respect to farm products for a period of one year from the date thereof, which shall at all times be open to the confidential inspection of the supervisor or the consignor or the authorized representative of either. The burden of proof shall be upon the commission merchant to prove the correctness of the commission merchant's accounting of any transaction which may be questioned.

C. Unless otherwise agreed to in writing, remittance in full of the amount realized from any sale, including collections, overcharges, and damages, less the agreed commission and other charges, accompanied by a complete statement of the transaction, shall be made to the consignor within 10 days after receipt of the money by the commission merchant.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-743. Recordkeeping and Reporting Requirements for Fruit and Vegetable Shippers

A. Every shipper shall keep a correct record of each shipment of each assessed commodity shipped, showing:
1. The name and address of each producer;
2. The shipment totals, by producer.

B. The shipper shall retain the original or a copy of records covering each shipment or transaction with respect to each assessed commodity shipped for a period of two years from the date thereof, which shall at all times be open to the confidential inspection of the supervisor or the authorized representative. The burden of proof shall be upon the shipper to prove the correctness of the shipper's accounting of any transaction which may be questioned.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).

ARTICLE 8. CITRUS FRUIT STANDARDIZATION

R3-4-801. Orange and Grapefruit Standards

A. Oranges are mature if, at the time of picking and at all times thereafter, the following conditions occur:
1. The juice contains soluble solids, as determined by a Brix Scale Hydrometer, of not less than eight parts to every part of acid contained in the juice, except in the case of Bloods, tangerines, tangelos, and mandarins. The acidity of the juice shall be calculated as citric acid without water or crystallization.
2. Not less than 90% of the oranges, by count, have attained a minimum characteristic yellow or orange color on at least 2/3 of the fruit surface, as indicated by Color Plate Number 20-L3 in A. Maerz and M. Rea Paul Dictionary of Color, first edition, published 1930, except in the case of Valencia oranges that have turned greenish after having reached the soluble solids requirement. This color standard is incorporated herein by reference and does not include any later amendments or editions of the incorporated matter and is on file with the Office of the Secretary of State and may also be examined in the Fruit and Vegetable Standardization Office, Arizona Department of Agriculture, 1688 West Adams, Phoenix, Arizona, 85007; or in the Fruit and Vegetable Division, AMS, U.S. Department of Agriculture, South Building, Washington, D.C. 20250.

B. Navels, at the time of sale, shall have not less than 90%, by count, a minimum characteristic yellow or orange color on at least 2/3 of the fruit surface.

C. Grapefruit are mature if, at the time of picking and at all times thereafter, the following conditions occur:
1. The juice contains soluble solids, as determined by a Brix Scale Hydrometer, of not less than six parts to every part of acid contained in the juice. The acidity of the juice shall be calculated as citric acid without water or crystallization.
2. Not less than 90% of the grapefruit, by count, have attained a minimum characteristic yellow or grapefruit color on at least 2/3 of the fruit surface as indicated by Color Plate Number 19-L3 in A. Maerz and M. Rea Paul Dictionary of Color, first edition, published 1930. This color standard is incorporated herein by reference and does not include any later amendments or editions of the incorporated matter and is on file with the Office of the Secretary of State and may also be examined in the Fruit and Vegetable Standardization Office, Arizona Department of Agriculture, 1688 West Adams, Phoenix, Arizona, 85007; or in the Fruit and Vegetable Division, AMS, U.S. Department of Agriculture, South Building, Washington, D.C. 20250.

Historical Note
Section R3-4-801 renumbered from R3-7-201 (Supp. 91-4). Section repealed, new Section adopted effective January 6, 1994 (Supp. 94-1).

R3-4-802. Lemon Standards

Lemons are mature when they have a juice content of 30% or more by volume, except that lemons packed for export to foreign markets other than Canada shall not be required to meet this standard.

Historical Note
Former Rule 1. Section R3-4-802 renumbered from R3-7-202 (Supp. 91-4). Section R3-4-802 repealed, new Section R3-4-802 renumbered from R3-4-806 and heading amended effective January 6, 1994 (Supp. 94-1).

R3-4-803. Lime Standards

Limes are mature and free from serious damage, except freezing or drying, if, at the time of picking and all times thereafter, the following conditions occur:
1. Damage is serious if 20% or more of the pulp shows staining, drying, desiccation, or a mushy condition.
2. Damage by freezing or drying is very serious if 40% or more of the pulp shows evidence of drying, desiccation, or a mushy condition.
3. Not more than 10%, by count, of the limes in any container or bulk lot may fail to meet the serious damage requirements prescribed in this Section. Not more than 5% shall be allowed for any one cause.
4. Not more than 15%, by count, of the limes in any container or bulk lot may fail to meet the serious damage requirements because of freezing or drying. Not more than 5% of this tolerance shall be allowed for very serious freezing or drying damage. Evidence of freezing or drying damage shall be determined by making as many cuts of each individual lime as are necessary.

Historical Note
Former Rule 2. Amended effective January 10, 1977 (Supp. 77-1). Amended effective November 3, 1983 (Supp. 83-6). Section R3-4-803 renumbered from R3-7-203 (Supp. 91-4). Former Section R3-4-803 renumbered to R3-4-809, new Section R3-4-803 adopted effective January 6, 1994 (Supp. 94-1).

R3-4-804. Tangerine, Tangelo, and Mandarin Standards

A. Definitions.
1. "Diameter" means the greatest dimension measured at a right angle to a straight line from the stem to the blossom end of the fruit.
2. "Tangerines, tangelos, or mandarins" means all varieties and hybrids of the mandarin group *citrus reticulata*.
3. "Serious damage" means damage caused by freezing or drying due to any condition if 20% or more of the pulp or edible portion of the fruit shows evidence of drying, desiccation, or a mushy condition. Evidence of damage shall be determined by as many cuts of each individual fruit as are necessary.

B. Tangerines, tangelos, and mandarins shall be:

1. Well colored; and
2. Free from serious damage by freezing or drying due to any cause; and
3. Free from decay.

C. Tangerines, tangelos, or mandarins are mature if, at the time of picking and at all times thereafter, not less than 90%, by count, of the tangerine type fruit have attained a minimum characteristic yellow or light green color on at least 2/3 of the fruit surface, as indicated by Color Plate Number 19-L3 in A. Maerz and M. Rea Paul Dictionary of Color, first edition, published 1930. This color standard is incorporated herein by reference and does not include any later amendments or editions of the incorporated matter and is on file with the Office of the Secretary of State and may also be examined in the Fruit and Vegetable Standardization Office, Arizona Department of Agriculture, 1688 West Adams, Phoenix, Arizona, 85007; or in the Fruit and Vegetable Division, AMS, U.S. Department of Agriculture, South Building, Washington, D.C. 20250.

D. Tangerines, tangelos, or mandarins shall meet the requirements prescribed in this Section if, at the time of sale, are well colored if 90%, by count, of the fruit in any lot show the yellow, orange, or red color of 75% or more of the surface of the fruit, and the fruit is free from serious damage.

E. Not more than 10%, by count, of the tangerines, tangelos, or mandarins in any one container or bulk lot may fail to meet the requirements, as prescribed in this Section, because of damage by freezing or drying due to any cause.

F. Not more than 5%, by count, of the tangerines, tangelos or mandarins in any one container or bulk lot may fail to meet the requirements prescribed in this Section because of serious decay.

Historical Note

Former Rule 3. Section R3-4-804 renumbered from R3-7-204 (Supp. 91-4). Former Section R3-4-804 renumbered to R3-4-807, new Section R3-4-804 adopted effective January 6, 1994 (Supp. 94-1).

R3-4-805. Serious Defects in Citrus Fruit

A. A defect is serious in citrus fruit, other than grapefruit, if the following conditions occur:
1. Any part of the fruit is affected with decay;
2. Damage by freezing or drying, if 20% or more of the pulp or edible portion of the fruit shows evidence of drying or a mushy condition or, in a lemon, of staining (except membranous stain). Evidence of damage shall be determined by making as many cuts on each fruit as may be necessary;
3. Injury, from any cause, if the skin (rind) is broken and the injury is not healed;
4. Scars, including those caused by insects, if they are dark, rough, or deep, and if an aggregate area of 25% or more of the fruit surface is affected;
5. Scale, if 50% or more of the fruit surface shows scale infestation in excess of 50 scales per square inch;
6. Dirt, smudge stain, sooty mold, rot residues, or other foreign material, if an aggregate area of 25% or more of the fruit surface is affected;
7. Staining, if 50% or more of the fruit surface is affected with a pronounced discoloration;
8. Greenish or brownish rind oil spots (oleocellosis), if an aggregate area of 25% or more of the fruit surface is affected;
9. Spotting or pitting, if the spots or pits are sunken and an aggregate area of 10% or more of the fruit surface is affected;
10. Sunburn in oranges, if it causes flattening of the fruit, or drying or discoloration of the skin (rind), or if it affects more than 1/3 of the fruit surface;
11. Sunburn in lemons, if 25% or more of the pulp or edible portion of the fruit shows evidence of drying, staining (except membranous stain), or a mushy condition. Evidence of damage shall be determined by making as many cuts on each lemon as may be necessary;
12. Aging, if 1/3 or more of the fruit surface is dried and hard;
13. Roughness in oranges, if 90% or more of the fruit surface is rough, coarse, or lumpy;
14. Softness in oranges, if the fruit is flabby, or if the orange is spongy and puffy over 90% or more of the fruit surface;
15. Water spot in oranges, if the affected skin (rind) is soft or not healed;
16. Protruding or enlarged navel end in oranges, if the navel end protrudes beyond the general contour of the orange to such extent, or the navel opening is so wide considering the size of the orange, or the navel growth is so folded or ridged, that it detracts from the appearance of the orange;
17. Damage to a lemon by internal decline, from any cause, if 20% or more of the pulp or edible portion shows evidence of drying, staining (except membranous stain), or a mushy condition, or if the core shows gumming for its entire length. Evidence of damage shall be determined by making as many cuts on each lemon as may be necessary;
18. Peteca in lemons, if the spots or pits are sunken and an aggregate area of 10% or more of the fruit surface is affected;
19. Deformities in lemons, if 50% or more of the individual fruit is excessively misshapen, ridgy, or lumpy; or
20. Red blotch in lemons, if an aggregate area of 10% or more of the fruit surface is affected.

B. A defect is serious in grapefruit if the following conditions for serious damage, as referenced in the United States Standards for Grades of Grapefruit (California and Arizona), effective December 27, 1999, occur:
1. Dryness or mushy condition, if it affects all segments for more than half of an inch at the stem end, or the equivalent of this amount by volume when it occurs in other portions of the fruit;
2. Sprayburn, if it changes the color to such an extent that the appearance of the fruit is seriously injured, or if it causes scarring that affects an aggregate area of more than 10% of the fruit surface;
3. Fumigation injury, if it causes small, thinly scattered spots over more than half of the fruit surface, or solid scarring or depressions that affect an aggregate area of more than 5% of the fruit surface;
4. Exanthema that occurs as small, thinly scattered spots over more than half of the fruit surface, or solid scarring that is not cracked, that affects an aggregate area of more than 5% of the fruit surface;
5. Scars that are very deep, or scars that are very rough or very hard if an aggregate area of more than one inch in diameter is affected;
6. Scars that are dark, rough, or deep, if an aggregate area of more than 5% of the fruit surface is affected;
7. Scars that are fairly light in color, slightly rough, or of slight depth, if an aggregate area of more than 15% of the fruit surface is affected;
8. Scars that are light colored, fairly smooth, with no depth, if an aggregate area of more than 25% of the fruit surface is affected;

9. Green spots, oil spots (oleocellosis), or other similar injuries that are soft, or that affect an aggregate area of more than 10% of the fruit surface;
10. Scale, if California red or purple scale is concentrated in a ring or blotch, or if it is more than thinly scattered over the fruit surface, or if the scale affects the appearance of the fruit to a greater extent;
11. Sunburn, if it causes flattening of the fruit, or drying or dark discoloration of the skin (rind), or if it affects more than 1/3 of the fruit surface;
12. Skin breakdown, if it exceeds a circle 5/8 of an inch in diameter;
13. Bruising, if segment walls are collapsed, or the albedo and juice sacs are ruptured;
14. Any part of the fruit is affected with decay;
15. Injury, from any cause, if the skin (rind) is broken and the injury is not healed;
16. Dirt, smudge stain, sooty mold, rot residues, or other foreign material, if an aggregate area of 25% or more or the fruit surface is affected; or
17. Any injury, by any means, if it seriously affects the appearance, or the edible or shipping quality of the fruit.

Historical Note

Former Rule 4. Section R3-4-805 renumbered from R3-7-205 (Supp. 91-4). Section repealed, new Section adopted effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 7 A.A.R. 5342, effective November 8, 2001 (Supp. 01-4).

R3-4-806. Tolerance for Serious Defects

A. Except as to the requirements relating to maturity and freezing or drying, as set forth in this Article, the following shall apply:
1. Not more than 10%, by count, of the oranges or grapefruit in any one container or bulk lot may be below the serious defect requirements, as prescribed in R3-4-805, and not more than 5% shall be allowed for any one cause.
2. Not more than 10%, by count, of the oranges or grapefruit in any one container or bulk lot may be seriously damaged by freezing or drying from any cause as shown by representative samples as set forth in R3-4-812.
3. When serious damage by freezing or drying from any cause is present, the combined tolerance for all defects shall not exceed 15%.

B. Except as to the requirements relating to freezing as set forth in R3-4-807, and internal decline, sunburn, or drying as set forth in R3-4-805, the following shall apply:
1. Not more than 10%, by count, of the lemons in any one container or bulk lot may be below the maturity requirements as set forth in R3-4-802 and the serious defect requirements as set forth in R3-4-805, and not more than 5% shall be allowed for any one cause.
2. Not more than 10%, by count, of the lemons in any one container or bulk lot may be seriously damaged by freezing, internal decline, sunburn, or drying from any cause as shown by representative samples as set forth in R3-4-812.
3. When serious damage by freezing, internal decline, sunburn, or drying from any cause is present, the combined tolerance of all defects shall not exceed 10%.

Historical Note

Former Rule 5. Section R3-4-806 renumbered from R3-7-206 (Supp. 91-4). Former Section R3-4-806 renumbered to R3-4-802, new Section R3-4-806 adopted effective January 6, 1994 (Supp. 94-1).

R3-4-807. Freezing Damage

Freezing damage is serious when:
1. Surface membranes show a water-soaked appearance or evidence of previous water soaking; or
2. The presence of crystals or crystalline deposits on the two surface membranes on each side of the two or more segments, as shown upon separation of the segments from one another. The section shall not be less than one inch or more than 1 1/2 inches in thickness of the central portion of the fruit obtained by cutting off a portion of each end. The evidence of freezing injury shall show the entire length, but not necessarily the entire area of the surface membrane.

Historical Note

Former Rule 6. Section R3-4-807 renumbered from R3-7-207 (Supp. 91-4). Section repealed, new Section R3-4-807 renumbered from R3-4-804 and amended effective January 6, 1994 (Supp. 94-1).

R3-4-808. Standards for Unlisted Citrus Fruit, Experimental Product Standards

A. The following standards shall apply for that citrus fruit for which specific quality standards are not otherwise established in this Article.

B. At least 90% by weight of all citrus fruit packed or offered for sale shall be free from insect injury which has penetrated or damaged the edible portion of the product and shall be free from worms, mold, decay, or other serious defects which damage the appearance or the shipping quality of the commodity as determined by an inspection of a representative sample prescribed in R3-4-812.

C. All experimental products shall be subject to the standards for unlisted citrus fruit prescribed in this Section and the requirements for labeling containers prescribed in R3-4-811.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-809. Bulk Sale of Citrus Fruit; Non-licensed Purchaser

If a non-licensed person purchases citrus fruit in bulk from a licensed citrus dealer for retail sale to the consumer, the non-licensed person shall possess a receipt or bill of lading for that lot. The licensed citrus fruit dealer shall ensure that the citrus fruit meets the minimum quality requirements of each commodity and the lot does not exceed 7,000 pounds.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 8 A.A.R. 3633, effective August 7, 2002 (Supp. 02-3).

R3-4-810. Packaged Count and Average Diameter

A. Oranges, grapefruit, and lemons, when packed or placed loose without packing in containers, shall be marked, by count, on the container and shall be one of the numbers tabulated in Packing Chart 1, Column A. The average diameter marked on the container shall be the corresponding number tabulated in Packing Chart 1, Column B. The average diameter, in inches, of the oranges, grapefruit, or lemons in the container as determined by inspection of a representative sample shall not be less than the corresponding measurements tabulated in Packing Chart 1, Column B for each fruit.
1. Oranges, grapefruit, and lemons, when placed loose without packing in containers, shall be placed in the container so compactly that they will not readily move in the container. The container shall be level full of fruit and the

count in the container shall be equal to the count marked with a permissible count not exceeding eight percent.

2. The count of oranges, grapefruit, and lemons, when place packed in the container shall be equal to or no more than five percent over the count marked on the container.
3. Oranges, grapefruit, and lemons may be packed in bulk containers. A bulk container shall contain no more than one size designation.

B. Lime containers shall be marked by size and shall be one of the numbers tabulated in Packing Chart 1, Column B. The average diameter, in inches, of the limes in the container, as determined by inspection of a representative sample, shall not be less than the corresponding measurements tabulated in Packing Chart 1, Column A. Each container shall be loosely packed and level full of limes.

PACKING CHART 1

ORANGES		GRAPEFRUIT		LEMONS		LIMES	
Column A	Column B	Column A	Column B	Column A	Column B	Column A	Column B
Count	Av. Dia.	Count	Av. Dia.	Count	Av. Dia.	Range	Size
24	4.370	9	6.200	63	2.925	2-5/16” to 2-5/8”	110
32	3.970	12	5.640	75	2.775	2-5/32” to 2-5/16”	150
36	3.820	14	5.350	95	2.570	2-1/16” to 2-5/32”	175
40	3.680	16	5.120	115	2.410	1-29/32” to 2-1/16”	200
48	3.470	18	4.920	140	2.240	1-25/32” to 1-29/32”	250
56	3.300	23	4.540	165	2.130	1-21/32” to 1-25/32”	275
72	3.040	27	4.270	200	2.010	1-9/16” to 1-21/32”	300
88	2.840	32	4.030	235	1.880		
113	2.600	36	3.880	285	1.770		
138	2.420	40	3.740	319	1.685		
163	2.290	48	3.530	343	1.640		
180	2.220	56	3.350				
210	2.070	64	3.170				
245	1.980	80	2.900				
270	1.920	88	2.840				

C. The diameter, in inches, of tangerines, tangelos, or mandarins in containers shall be marked with one of the size designations tabulated in Column A of Packing Chart 2 and shall be between the measurements tabulated in corresponding lines of Column B and Column C; provided that the diameter, in inches, of not more than 10 percent, by count, of the fruit in the container measures less than the corresponding measurement in Column B, and not more than the corresponding measurement in Column C.

PACKING CHART 2

COLUMN A	COLUMN B	COLUMN C
OMG	4.25+	
Ultra Colossal	3.75	4.25
Super Colossal	3.25	3.75
Colossal	3.00	3.25
Mammoth	2.75	3.00
Jumbo	2.50	2.75
Large	2.25	2.50
Medium	2.00	2.25
Small	1.75	2.00

D. Minneola tangelos may be packed, by count, using Packing Chart 2, or Packing Chart 3.

PACKING CHART 3

	COUNT	AVERAGE DIAMETER	PACK PATTERN	ROWS	LAYERS
OMG	36	4.25	4x4	3	3
OMG	40	4.00	3x2	4	4
Super Ultra Colossal	48	3.75	3x3	4	4
Super Ultra Colossal	48	3.75	4x4	3	4
Ultra Colossal	56	3.50	4x3	4	4
Super Colossal	64	3.315	4x4	4	4
Colossal	80	3.125	5x5	4	4
Mammoth	100	2.875	4x4	5	5
Jumbo	125	2.625	5x5	5	5
Large	150	2.375	6x6	5	5
Medium	180	2.125	5x5	6	6
Small	210	1.875	6x6	6	6

E. If a bulk container of tangerines, tangelos, or mandarins is marked with the words “irregular sizes,” the tangerines, tangelos, or mandarins in the bulk container are exempt from the size requirements in Packing Chart 2 and Packing Chart 3.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 8 A.A.R. 3633, effective August 7, 2002 (Supp. 02-3).

R3-4-811. Container Labeling for Citrus Fruit

A. All containers shall bear in plain sight and plain letters on one outside panel the following:
1. Shipper or customer identification:
   a. The name of the shipper; and
   b. The city, state, and zip code of the shipper; or
   c. The name, address, and logo of the customer; and
   d. The shipper’s identifying code.
2. The common or generic name of the commodity in each container; and
3. The count, measure, or net weight of the commodity contained in each container, except for bulk containers.

B. If a shipper or customer reuses a container bearing the name of a different shipper or customer, the shipper or customer shall remove or obliterate all markings or labels from the container before commercial reuse.

C. Citrus fruit for processing.
1. If a pallet or container is clearly marked “FOR PROCESSING ONLY,” the information in subsection (A) is not required if the pallet or container is used to transport fruit or vegetables to a processing plant.
2. Fruit or vegetables transported to a processing plant may be packed on a pallet or in a container bearing a label for a commodity other than the commodity within the container.

Historical Note

Adopted effective January 6, 1994 (Supp. 94-1). Amended by final rulemaking at 6 A.A.R. 143, effective December 8, 1999 (Supp. 99-4).

R3-4-812. Inspections and Representative Sampling for Citrus Fruit

A. An inspector shall conduct a preliminary inspection of each commodity which includes a visual and physical inspection of specimens of the commodity. When determining compliance of a field packing operation, the inspector shall select specimens from widely separated areas of the packing operation. When determining compliance in a packing shed, warehouse, fruit stand, retail store, or other business which sells citrus fruit, containers shall be selected at random from widely separated parts of the lot. If one-half of the containers or specimens in the containers of the lot or field packing operation comply with the requirements of this Article and the other half of the containers or specimens in the containers of the lot or field packing operation do not, an equal number of containers or specimens in the containers shall be examined from each half.

B. If, after the preliminary inspection, the inspector determines that the quality of the product clearly meets or exceeds the requirements of this Article, the inspector need not complete a comprehensive inspection. If, after the preliminary inspection, the inspector suspects there may be a failure to comply with the requirements of this Article, the inspector shall complete the procedures for a comprehensive inspection.

C. For a comprehensive inspection of a field or shed packing operation, all specimens in each container of the official sample shall be examined by an inspector. For a comprehensive inspection of a wholesale warehouse, fruit stand, retail store, or any other business dealing with the sale of citrus fruit, an inspector may examine all specimens in each container of the official sample. The official sample of the lot shall consist of an inspection of no less than two containers for the first 100 containers of the lot and one container for every 100 containers thereafter. For example:

No. of Containers	Containers Sampled
2-100	2
101-200	3
201-300	4
301-400	5
401-500	6

D. In a comprehensive inspection of a wholesale warehouse, fruit stand, retail store, or any other business dealing with the sale of citrus fruit, an inspector need only examine a portion of the specimens in each container of the official sample. The official sample of the lot shall consist of an inspection of no less than the following:

No. of Containers	Containers Sampled
less than 10	2
10-30	3
31-50	4
51-100	5
101-200	6
201-300	8
301-500	10

E. If only a portion of the specimens in each container of the official sample is examined during a comprehensive inspection in lots in excess of 500 containers, the official sample shall consist of the number of containers equal to at least 1/2 the square root of the total number of containers in the lot. For example:

No. of Containers	Containers Sampled
501-600	12
601-700	13
701-800	14
801-900	15
901-1000	16

F. Individual containers in any lot may contain up to double the amount of serious damage and other requirements prescribed for that commodity as long as the percentage of all requirements in the entire lot averages within the percent allowable as determined by inspection of a representative sample.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-813. Reconditioning for Citrus Fruit

A. Any lot or part of a lot in a grower and shipper packing facility which is found to be in violation of Article 8 of these rules shall be reconditioned within 72 hours, pursuant to A.R.S. § 3-445(B)(5). If the lot or part of a lot is not brought into compliance within the established time limit, an inspector shall proceed with the provisions as prescribed in A.R.S. § 3-444.

B. Any lot or part of a lot in a wholesale warehouse, fruit stand, retail store, or any other business dealing in the sale of fruit and vegetables which is found to be in violation of Article 8 of these rules shall be reconditioned within 48 hours, pursuant to A.R.S. § 3-445(B)(5). If the lot or part of the lot is not brought into compliance within the established time limit, an inspector shall proceed with the provisions, as prescribed in A.R.S. § 3-444.

C. Time-limit extensions shall be granted provided that the holder of the product held in violation requests a specific deadline, by facsimile or by letter, to the office of the supervisor. A lot or part of a lot not reconditioned by the requested extension time shall be dealt with according to the provisions, as prescribed in A.R.S. § 3-444.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-814. Experimental Pack and Product Permits for Citrus Fruit

A. An applicant for a permit for the use of "experimental packs" or "experimental products" under A.R.S. § 3-445(B)(3), shall provide the following information on a form furnished by the Department:
1. The name, company name, address, and telephone number of the applicant;
2. The name and description of the product packed in the container;
3. The description of the arrangement of the product packed in the container; and
4. The period for use of the experimental pack or product.

B. All experimental products shall conform to the standards prescribed in this Article.

C. Upon completion of permit requirements, the supervisor shall grant a permit that is valid for one year from the date of issuance.

D. An applicant may request renewal of an experimental pack or product permit. The Department shall not grant a renewal permit for the same experimental pack or product for more than three consecutive years, unless the rulemaking process, prescribed under A.R.S. § 3-446, to standardize the experimental pack or product is initiated.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).
Amended by final rulemaking at 8 A.A.R. 3633, effective August 7, 2002 (Supp. 02-3).

R3-4-815. Recordkeeping and Reporting Requirements for Citrus Fruit Commission Merchants

A. Every commission merchant shall keep a correct record of each consignment of farm products received for sale showing:
1. The name and address of the consignor;
2. The date of the consignment received;
3. The condition and quantity of produce upon arrival;
4. The date of the sale;
5. The price for which sold;
6. An itemized statement of charges to be paid by the consignor;
7. The names and addresses of purchasers if the commission merchant has a financial interest in the business of the purchasers, or if the purchasers have a financial interest in the business of the commission merchant, either directly or indirectly, as holder of the other's corporate stock, as partner, as lender, or borrower of money to or from the other, or otherwise;
8. The lot number or other identifying mark of each consignment;
9. All claims filed by the commission merchant against any person for overcharges or for damages resulting from the injury of the person.

B. The commission merchant shall retain the original or a copy of records covering each sale or transaction with respect to farm products for a period of one year from the date thereof, which shall at all times be open to the confidential inspection of the supervisor or the consignor, or the authorized representative of either. The burden of proof shall be upon the commission merchant to prove the correctness of the commission merchant's accounting of any transaction which may be questioned.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).

R3-4-816. Recordkeeping and Reporting Requirements for Citrus Fruit Shippers

A. Every shipper shall keep a correct record of each shipment of each assessed citrus commodity shipped, showing:
1. The name and address of the producer;
2. The shipment totals, by producer.

B. The shipper shall retain the original or a copy of records covering each shipment or transaction with respect to each assessed citrus commodity shipped for a period of two years from the date thereof, which shall at all times be open to the confidential inspection of the supervisor or the authorized representative. The burden of proof shall be upon the shipper to prove the correctness of the shipper's accounting of any transaction which may be questioned.

Historical Note
Adopted effective January 6, 1994 (Supp. 94-1).

ARTICLE 9. BIOTECHNOLOGY

R3-4-901. Genetically Engineered Organisms and Products

A. Definitions. In addition to the definitions provided in A.R.S. § 3-101, the following shall apply:

1. "Associate Director" means the Associate Director of the Plant Services Division of the Arizona Department of Agriculture.
2. "Genetically engineered" means the genetic modification of organisms by recombinant DNA techniques, including genetic combinations resulting in novel organisms or genetic combinations that would not naturally occur.
3. "Organisms" means any active, infective, or dormant stage or life form of any entity characterized as living, including vertebrate and invertebrate animals, plants, bacteria, fungi, mycoplasms, mycoplasma-like organisms, as well as entities such as viroid, viruses, or any entity characterized as living related to the foregoing.
4. "Permit" means an application which has been approved by USDA and the Department.
5. "Permit application" means an application filed with USDA, which may be supplemented with requirements from the Department, for the introduction of genetically engineered organisms and products, as provided by 7 CFR 340, revised June 16, 1987, pages 22908 through 22915. The material incorporated herein by reference is on file with the Office of the Secretary of State and does not include any later amendments or editions of the incorporated matter.
6. "Product" means plant reproductive parts including pollen, seeds, and fruit, spores, or eggs.
7. "USDA" means the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA, APHIS, PPQ).

B. Permit applications. A genetically engineered organism or product shall not be introduced into Arizona, sold, offered for sale, or distributed for release into Arizona's environment unless a permit issued pursuant to the application has been issued by USDA, or the Department has been notified by the USDA that the genetically engineered organisms or product is eligible under the notification procedure, as prescribed by 7 CFR 340.3, revised April 1993, or it has been determined by the USDA to be of nonregulated status, as prescribed by 7 CFR 340.6, revised April 1993. The material incorporated herein by reference is on file with the Office of the Secretary of State and does not include any later amendments or editions of the incorporated matter.

1. Applicants for the release or use of genetically engineered organisms or products shall follow all permit application procedures required by USDA.
2. In addition to USDA's requirements, permit applications shall demonstrate to the Department that:
   a. Genetically engineered organisms or products shall be handled in such a manner so that no genetically engineered organism or product accidentally escapes into Arizona's environment.
   b. All permit applicants shall comply with Arizona quarantine rules regulating the plants, pests, or organisms being introduced into Arizona.
3. The Department may, if it deems necessary to protect agriculture, public health, or the environment from potential adverse effects from the introduction of a specific genetically engineered organism or product:
   a. Place restrictions on the number and location of organisms or products released, method of release, training of persons involved with the release of organisms or products, disposal of organisms or products, and other conditions of use;
   b. Require measures to limit dispersal of released organisms or spread of inserted genes or gene products;
   c. Require monitoring of the abundance and dispersal of the released organism or inserted genes or gene products;
   d. Request the USDA to deny, suspend, modify, or revoke the permit for failure to comply with this rule.
   e. Request the USDA to suspend the permit if it is determined that an adverse effect is occurring or is likely to occur because of a release authorized by such permit.
4. To the extent possible, the Department shall accept for review and base its decision on the data submitted with the federal application. However, the Department may request additional information from the applicant to assess the risks to animals and plants, including risks of vector transmissions of genetically engineered organisms or products.
5. The Associate Director shall review the application recommendations with the Director who shall, within the time period prescribed on each USDA application, approve, conditionally approve, or deny the permit.
6. The Director shall return the completed application with the resolution to USDA for final action.

Historical Note

Adopted effective November 22, 1993 (Supp. 93-4).

This page intentionally left blank

Nevada

This page intentionally left blank

NEVADA NOXIOUS WEED LIST BY CATEGORY

(NAC 555.010)

Category A Weeds:

Category A noxious weeds are weeds that are generally not found or that are limited in distribution throughout the State.

African rue	(*Peganum harmala*)
Austrian fieldcress	(*Rorippa austriaca*)
Swainsonpea	(*Sphaerophysa salsula*)
Black henbane	(*Hyoscyamus niger*)
Camelthorn	(*Alhagi* maurorum)
Common crupina	(*Crupina vulgaris*)
Dalmatian toadflax	(*Linaria dalmatica*)
Dyer's woad	(*Isatis tinctoria*)
Eurasian water-milfoil	(*Myriophyllum spicatum*)
Giant reed	(*Arundo donax*)
Giant salvinia	(*Salvinia molesta*)
Goatsrue	(*Galega officinalis*)
Crimson fountain grass	(*Pennisetum setaceum*)
Houndstongue	(*Cynoglossum officinale*)
Hydrilla	(*Hydrilla verticillata*)
Iberian starthistle	(*Centaurea iberica*)
Common St. Johnswort	(*Hypericum perforatum*)
Malta starthistle	(*Centaurea melitensis*)
Mayweed chamomile	(*Anthemis cotula*)
Mediterranean sage	(*Salvia aethiopis*)
Purple loosestrife	(*Lythrum salicaria, L. virgatum* & cultivars)
Purple starthistle	(*Centaurea calcitrapa*)
Rush skeletonweed	(*Chondrilla juncea*)
Sow thistle	(*Sonchus arvensis*)
Spotted knapweed	(*Centaurea maculosa*)
Squarrose knapweed	(*Centaurea virgata*)
Sulfur cinquefoil	(*Potentilla recta*)
Syrian bean caper	(*Zygophyllum fabago*)
Yellow starthistle	(*Centaurea solstitialis*)
Yellow toadflax	(*Linaria vulgaris*)

Category B Weeds:

Category B listed noxious weeds are weeds that are generally established in scattered populations in some counties of the State.

Horsenettle	(*Solanum carolinense*)
Diffuse knapweed	(*Centaurea diffusa*)
Leafy spurge	(*Euphorbia esula*)
Medusahead	(*Taeniatherum caput-medusae*)
Musk thistle	(*Carduus nutans*)
Russian knapweed	(*Acroptilon repens*)
African mustard	(*Brassica tournefortii*)
Scotch thistle	(*Onopordum acanthium*)
Silverleaf nightshade	(*Solanum elaeagnifolium*)

Category C Weeds:

Category C listed noxious weeds are weeds that are generally established and generally widespread in many counties of the State.

Canada thistle	(*Cirsium arvense*)
Hoary cress	(*Cardaria draba*)
Johnsongrass	(*Sorghum halepense*)
Perennial pepperweed	(*Lepidium latifolium*)
Poison-hemlock	(*Conium maculatum*)
Puncture vine	(*Tribulus terrestris*)
Salt cedar (tamarisk)	(*Tamarix* spp.)
Spotted water hemlock	(*Cicuta maculata*)

This page intentionally left blank

Utah

This page intentionally left blank

Utah Noxious Weed List

October 2010

The following weeds are hereby officially designated and published as noxious for the State of Utah, as per the authority vested in the Commissioner of Agriculture and Food under Section 4-17-3, Utah Noxious Weed Act:

There are hereby designated three classes of noxious weeds in the state: Class A (EDRR) Class B (Control) and Class C (Containment).

Class A: Early Detection Rapid Response (EDRR) Declared noxious weeds not native to the sate of Utah that pose a serious threat to the state and should be considered as a very high priority.

Black henbane	*Hyoscyamus niger (L.)*
Diffuse knapweed	*Centaurea diffusa (Lam.)*
Leafy spurge	*Euphorbia esula L.*
Medusahead	*Taeniatherum caput-medusae*
Ox-Eye daisy	*Chrysanthemum leucanthemum L.*
Perennial Sorghum spp. including but not limited to:	
Johnsongrass	*Sorghum halepense (L.) Pers.*
and Sorghum almum	*Sorghum almum, Parodi*
Purple loosestrife	*Lythrum salicaria L.*
Spotted knapweed	*Centaurea maculosa Lam.*
Squarrose knapweed	*Centaurea squarrosa Gugle.*
St. Johnswort	*Hypericum perforatum L.*
Sulfur cinquefoil	*Potentilla recta L.*
Yellow starthistle	*Centaurea solstitialis L.*
Yellow toadflax	*Linaria vulgaris Mill.*

Class B: (Control) Declared noxious weeds not native to the state of Utah that pose a threat to the state and should be considered a high priority for control.

Bermudagrass*	*Cynodon dactylon (L.) Pers.*
Broad-leaved peppergrass (Tall whitetop)	*Lepidium latifolium L.*
Dalmatian toadflax	*Linaria dalmatica (L.) Mill.*
Dyers woad	*Isatis tinctoria L.*
Hoary cress	*Cardaria spp.*
Musk thistle	*Carduus nutans L.*
Poison hemlock	*Conium maculatum L.*
Russian knapweed	*Centaurea repens L.*
Scotch thistle (Cotton thistle)	*Onopordium acanthium L.*

Squarrose knapweed	*Centaurea virgata Lam. ssp*

Class C: (Containment) Declared noxious weeds not native to the sate of Utah that are widely spread but pose a threat to the agricultural industry and agricultural products with a focus on stopping expansion.

Field bindweed (Wild morning-glory)	*Convolvulus spp.*
Canada thistle	*Cirsium arvense (L.) Scop.*
Houndstounge	*Cynoglossum officianale L.*
Saltcedar	*Tamarix ramosissima Ledeb.*
Quackgrass	*Agropyron repens (L.) Beauv.*

*Bermudagrass (*Cynodon dactylon*) shall not be a noxious weed in Washington County and shall not be subject to provisions of the Utah Noxious Weed Law within the boundaries of that county. It shall be a noxious weed throughout all other areas of the State of Utah and shall be subject to the laws therein.

Appendix 3.13-A

Injury Effects Methodology

This page intentionally left blank

Contents

1.0 Introduction **3.13-A1**

2.0 Methodology **3.13-A1**

2.1 Southwest Gap Region 3.13-A1

2.1.1 Selenium 3.13-A1

2.1.2 Mercury 3.13-A5

2.2 San Juan River 3.13-A5

2.2.2 Selenium 3.13-A10

3.0 References **3.13-A15**

List of Tables

Table 1 Navajo Generating Station (NGS) and Other Cumulative Sources (OCS) percent Contribution of Mercury (Hg) and Selenium (Se) to the Water Column, Razorback Sucker Surrogates, and Humpback Chub (and Surrogates) 3.13-A5

List of Figures

Figure 1 Conceptual Model to Determine NGS Effects on Humpback Chub and Razorback Sucker in the Southwest Gap Region 3.13-A2

Figure 2 General Fish Egg Survival Based on Selenium Concentration in Eggs 3.13-A3

Figure 3 Razorback Sucker Specific Egg Survival Based on Selenium Concentration in Eggs 3.13-A4

Figure 4 Conceptual Model to Determine NGS Effects on Colorado Pikeminnow and Razorback Sucker in the San Juan River 3.13-A6

Figure 5 Growth Function for Colorado Pikeminnow Used in the FCPP BO (‘SJR CPM Lengths Using Best Fit’) 3.13-A8

Figure 6 Mercury Concentrations in Colorado Pikeminnow in the Upper Colorado River Basin Based on Total Body Length (Osmundson and Lusk 2011) 3.13-A9

Figure 7 Refined Mercury Effect Curves for the Colorado Pikeminnow PVA 3.13-A10

Figure 8 Colorado Pikeminnow Specific Egg Survival Regression Based on Selenium in Eggs 3.13-A11

Figure 9 General Egg Survival Regression Based on Selenium in Eggs 3.13-A12

Figure 10 Razorback Sucker Specific Egg Survival Based on Selenium Concentration in Eggs 3.13-A13

Figure 11 Biphasic relationship developed by Lusk (personal communication 2015) based on a model by Beckon et al. (2008) and data from several studies (Beyers and Sodergren 1999, Hamilton et al. 2001a,b, 1999). 3.13-A14

1.0 Introduction

Quantification of injury effects on individual fish was made for two federally listed species in the San Juan River (Colorado pikeminnow and razorback sucker) and the Southwest Gap Region (humpback chub and razorback sucker). The injury effect analyses were conducted by the USFWS Ecological Services Field Office in Phoenix, Arizona. Results are considered to be preliminary at this time. Injury effects will be finalized in the Biological Opinion for this project. A summary of the San Juan River and Southwest Gap Region analyses are described below.

- Southwest Gap Region – The injury estimate for the Southwest Gap Region was done using population data for humpback chub and the recovery unit population goal for razorback sucker (5,600 adults). Mercury and selenium toxicity dose-response curves for the various life stages of fish (eggs/embryos, larvae, juveniles, and adults) were applied to the population estimates. The total number of individuals injured was estimated for the project period of 2020 to 2044, and was extended to 2074 to capture indirect effects (later in time) of emissions. The injury estimate was calculated for baseline, project impact, and other cumulative emission sources.
- San Juan River – The injury estimate for the San Juan River was done using (1) population data for Colorado pikeminnow in combination with (2) mercury toxicity dose-response curves for the various life stages of the species (eggs/embryos, larvae, juveniles, and adults) and (3) estimated total cumulative dose from baseline, NGS emissions and other cumulative sources. Injury was estimated for subadults (juveniles) and adults based on effects most likely to impact individuals including reproduction, survival, and growth. Injurious effects of mercury on fish behavior (e.g., reduced predator avoidance) were expressed as the number of individuals affected (Shibata 2014). The total number of individuals potentially injured was estimated for the entire period of 2020 to 2074 and was calculated for baseline, project impact, and other cumulative emission sources.

Descriptions of the injury effects analyses are provided in the following sections for the Southwest Gap Region and San Juan River.

2.0 Methodology

2.1 Southwest Gap Region

2.1.1 Selenium

Quantification of effects on individual humpback chub and razorback sucker in the Southwest Gap Region involved a series of steps that determined selenium concentration in fish and fish eggs, egg survival, and the number of individuals affected by NGS emissions (**Figure 1**). The following analyses were used for these steps.

2.1.1.1 Concentration in Fish

<u>Humpback Chub</u>

An average selenium concentration for the humpback chub (16.0 mg/kg dw) was determined using a low concentration from Kepner (1988 [humpback chub, 2.0 mg/kg]) and a high concentration from Walters et al. (2015 [trout, 29.1 mg/kg]). Average concentrations were used because this was a preliminary effects analysis and data were limited.

Razorback Sucker

An average selenium concentration for the razorback sucker (8.8 mg/kg dw) was determined using a low concentration from Walters et al. (2015 [bluehead sucker, 6.0 mg/kg]) and a high concentration from Walters et al. (2015 [flannelmouth sucker, 11.5 mg/kg]). Average concentrations were used because this was a preliminary effects analysis and data were limited.

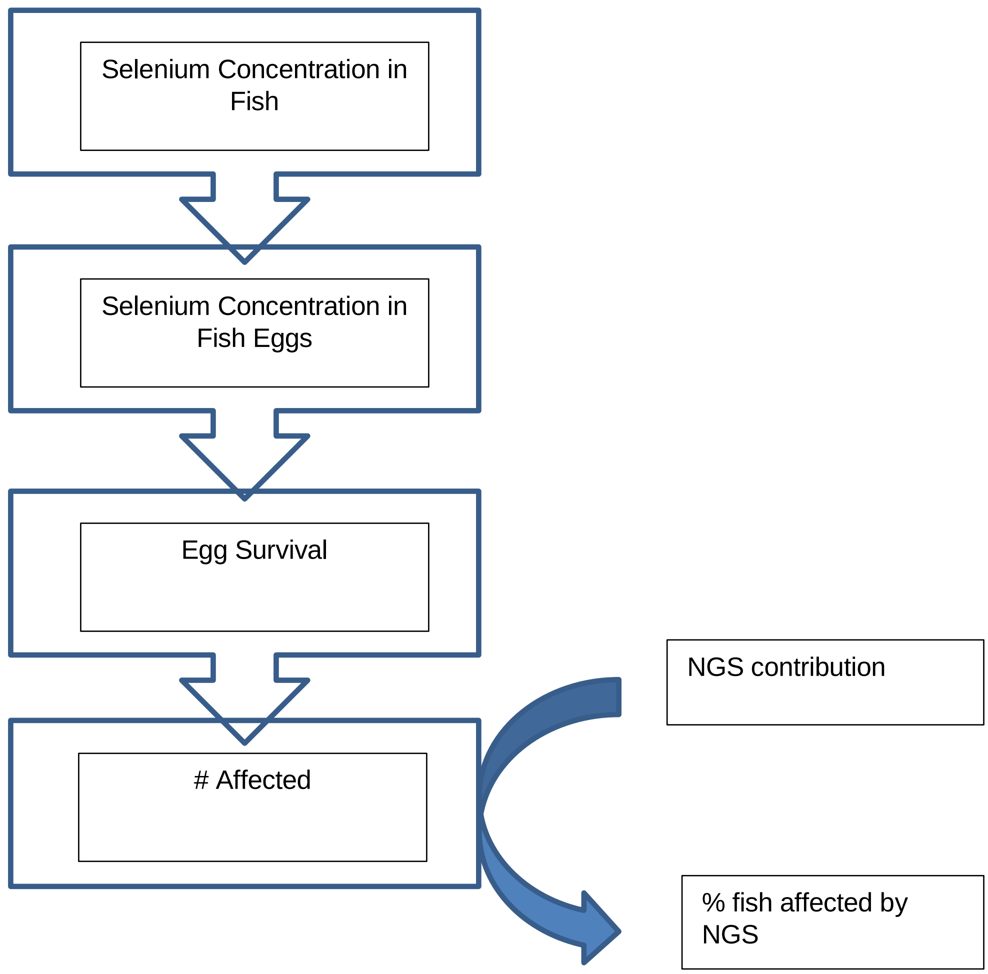


Figure 1 Conceptual Model to Determine NGS Effects on Humpback Chub and Razorback Sucker in the Southwest Gap Region

2.1.1.2 Concentration in Eggs

Humpback Chub

Selenium transfer factors from adult female fish to eggs were based on studies in the literature to determine selenium concentrations in eggs. Equations from Osmundson and Skorupa (2011), Osmundson et al. (2007), and Buhl and Hamilton (2000) were used. The results were averaged to create a single output for the next step. This output was then carried forward to determine egg survival. The following equations were used:

Equation 1 (Osmundson and Skorupa 2011): $y=e^{(0.7091*(\ln(\text{average fish tissue concentration})+0.6733)))}$

Equation 2 Roundtail chub pre-spawn (Osmundson et al. 2007) $y = =e^{((0.9384*(LN(\text{ave fish tissue conc})))+0.815)}$

Equation 3 Roundtail chub All (Osmundson et al. 2007) $y =e^{((1.3966*(LN(\text{ave fish tissue conc})))-0.1945)}$

<u>Razorback sucker</u>

Equation 4: = (average fish tissue Se concentration) *1.43

Equation 5 (Hamilton et al. 2001): $=e^{((1.3*(\ln(\text{average fish tissue Se concentration})))-0.0575)}$

2.1.1.3 Egg Survival

<u>Humpback chub</u>

The egg concentration was plugged into an equation to determine egg survival. This equation was determined using data from a variety of warmwater fish species: Doroshov 1992 (Table 10 (channel catfish) and 19 and 20 (bluegill), Buhl and Hamilton (2000; Colorado pikeminnow), Coyle et al. (1993; bluegill); Hamilton et al. (2002; razorback sucker); and Hamilton et al. (2001; razorback sucker). The general fish egg survival estimates for selenium are shown in **Figure 2**.

Equation 6: $y= -0.121*\ln(\text{egg concentration}) + 0.9401$

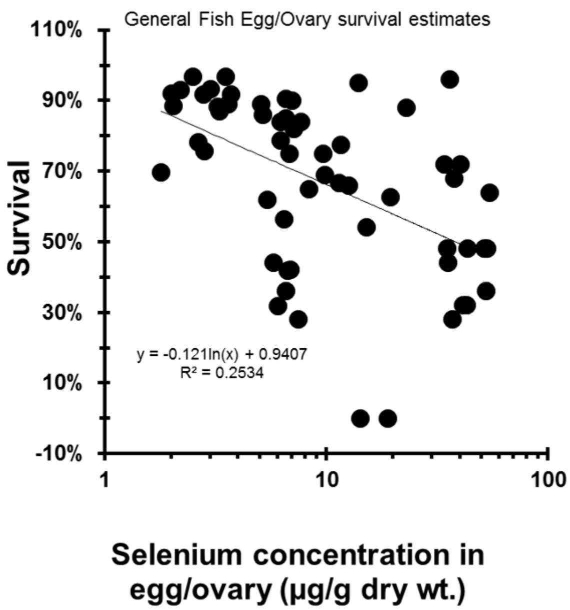


Figure 2 General Fish Egg Survival Based on Selenium Concentration in Eggs

<u>Razorback Sucker</u>

Razorback sucker specific egg survival (y) $=-0.087*\ln(\text{egg Se concentration})+0.839$

Data for razorback sucker egg survival were available to determine the equation (J Lusk, pers comm. 2016) using data from Hamilton et al. (2002; razorback sucker) and Hamilton et al. (2001; razorback sucker), and Hamilton et al. (2005 a,b,c). Razorback sucker egg survival from selenium is shown in **Figure 3**.

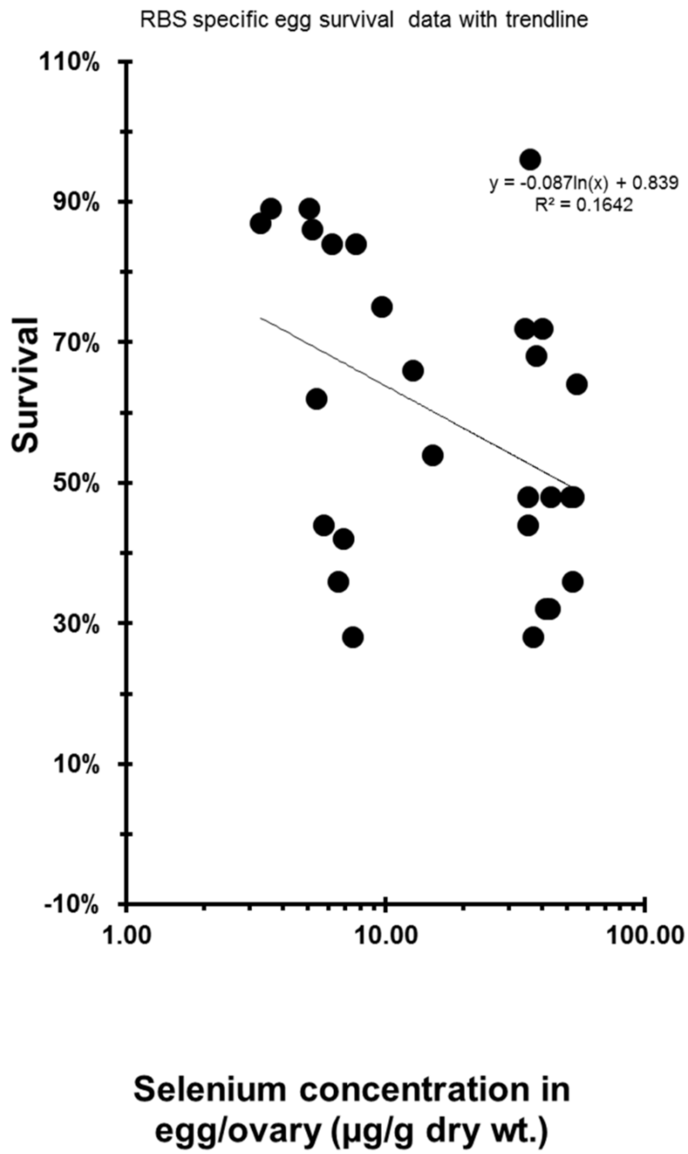


Figure 3 Razorback Sucker Specific Egg Survival Based on Selenium Concentration in Eggs

2.1.1.4 Number of Individuals Affected

Baseline selenium concentrations were determined using Kepner (1988) and Walters et al. (2015). Future Se concentrations were determined by using data from Ramboll Environ's Gap Region ERA B2 and OCS (Other Cumulative Sources) summaries (Ramboll Environ 2016). To determine mortality due to baseline selenium concentrations, the percent mortality was determined using 100-percent survival. To determine the amount individual fish injured due to NGS operations, it was assumed that NGS' contribution of selenium to Marble Canyon (e.g., Glen Canyon Dam to the confluence with the Little Colorado River) would be the same as the San Juan River from EPRI (2016) (NGS), which was combined with the baseline value. NGS' contribution was modeled from 2019 – 2047 although most of that effect occurs from 2027-2052. The percent selenium due to NGS peaks in 2038 at 44 percent (Figure 10-6 in EPRI 2016).

2.1.2 Mercury

The effects of mercury due to the NGS, baseline, B2, and OCS water concentrations, in addition to baseline fish tissue concentrations from Ramboll Environ (2016) were used to derive the NGS contribution of 0.13 percent by 2074 (**Table 1**, blue oval). The NGS percent contribution was then applied to the amount of take or individual fish injury in the FCPP BO's contribution. The humpback chub's take is estimated from the Colorado pikeminnow's take numbers, since they are both representative of the minnow family (i.e., cyprinids).

Table 1 Navajo Generating Station (NGS) and Other Cumulative Sources (OCS) percent Contribution of Mercury (Hg) and Selenium (Se) to the Water Column, Razorback Sucker Surrogates, and Humpback Chub (and Surrogates)

	% Hg due to NGS	% Hg due to OCS	% Se due to NGS	% Se due to OCS
water	0.11%	20.61%	0.01%	0.00004%
--RZB surrogates				
BHS (Walters)	0.11%	77%	0.05%	0.0003%
FMS (Walters)	0.06%	42%	0.03%	0.0002%
HBC (Kepner)	0.12%	81%	0.11%	0.0006%
--HBC surrogate				
RATR (Walters)	0.03%	21%	0.01%	0.0001%
RATR (Vanderkooi)	0.13%	86%	NA	NA
average	0.09%	61%	0.05%	0.0003%

2.2 San Juan River

The steps taken in the Four Corners Power Plant (FCPP) Biological Opinion (BO) to determine the injury effects and amount of take due to the operation of the plant over 25 years are essentially the same as those described for the Southwest Gap Region and NGS plant (Section 2.1). The differences are the area of concern, which is the San Juan River, instead of the Colorado River in the Grand Canyon. One fish species of concern, razorback sucker, is the same as analyzed in the Southwest Gap Region analysis. The Colorado pikeminnow is the other species of concern in the FCPP BO.

Quantification of effects on individual humpback chub and razorback sucker in the Southwest Gap Region involved a series of steps that determined selenium concentration in fish and fish eggs, egg survival, and the number of individuals affects by NGS emissions (**Figure 4**). The following analyses were used for these steps.

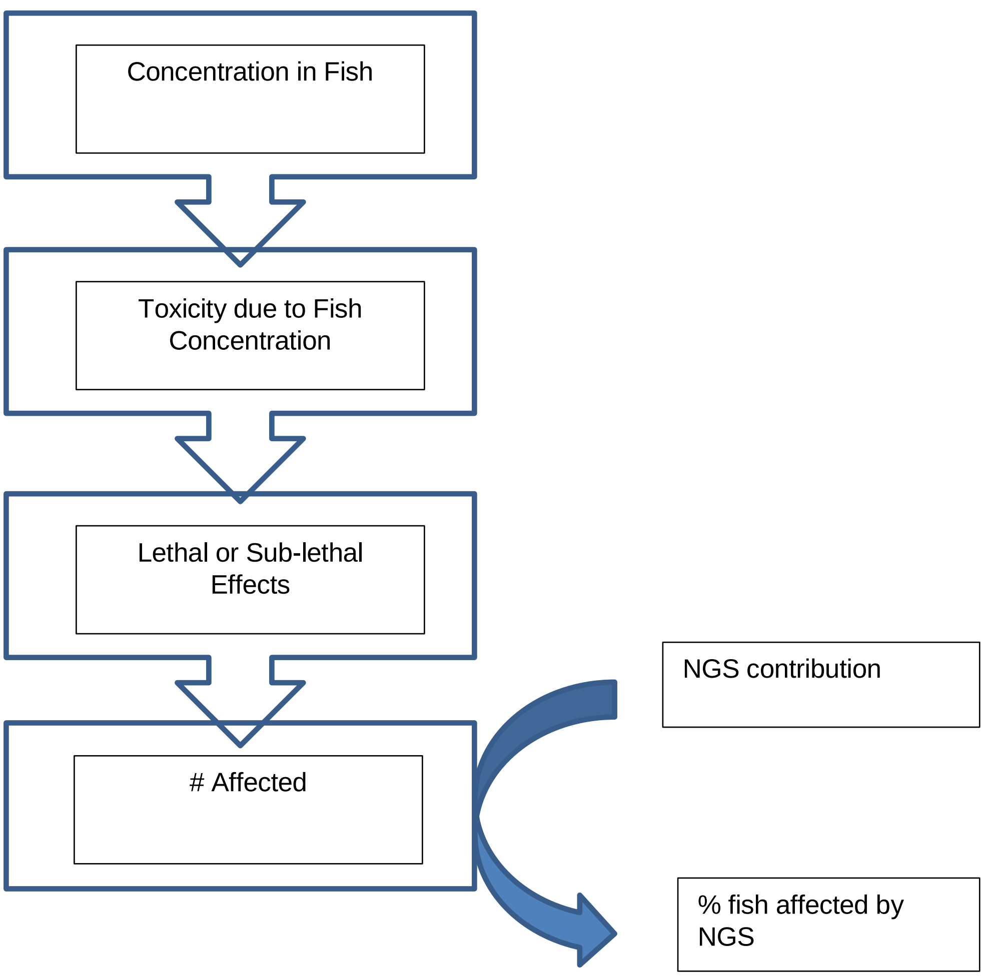


Figure 4 Conceptual Model to Determine NGS Effects on Colorado Pikeminnow and Razorback Sucker in the San Juan River

2.2.1 Mercury

NGS's mercury contribution to Colorado pikeminnow fish tissue is 13 percent of FCPP's contribution. This value was determined after considering that the FCPP contribution to mercury in Colorado pikeminnow fish tissue was 0.3 percent of the total mercury in the fish (EPRI 2014, page 11-8) and the NGS contribution of mercury in Colorado pikeminnow tissue is 0.035 percent (EPRI 2016, page 10-11).

$$\frac{0.04\%\ \text{(rounded up)}}{0.3\%} = .13 \text{ or } 13\%$$

Since the mercury bioaccumulation into razorback sucker tissue will be lower than the Colorado pikeminnow, the same calculations from FCPP for the razorback sucker were used to quantify the number of adverse effects in the razorback sucker and were multiplied by 13 percent.

Next, the steps below describe how the FCPP BO determined the amount and types of incidental take due to mercury from FCPP operations in the Colorado pikeminnow and razorback sucker. More details are provided to further explain some of the specifics in each step.

1) The Population Viability Analysis (PVA) model was built by a panel of Colorado pikeminnow experts. Life history parameters in the model were used to estimate Colorado pikeminnow population dynamics under a variety of scenarios. The output of the model was the total number of Colorado pikeminnow in the San Juan River population, divided into cohorts from egg, age 0 (= larvae), to age 10+) from 2016-2074. A stable or recovered San Juan River Colorado pikeminnow population was used for the FCPP BO analysis.

2) Maximum mercury concentrations in tissue for Colorado pikeminnow total lengths <400 mm and >400 mm due to FCPP operations were compiled.

3) Length, weight, age, and mercury concentration data for Colorado pikeminnow in the Upper Colorado River Basin were compared to San Juan River data. A regression for Colorado pikeminnow total length by age was combined with the PVA output data for the number of fish in each age class. The result was the length of fish in each age class. Then, the length of the fish was used to determine the baseline mercury concentration of fish in each age class.

4) Future mercury tissue concentrations were calculated by age class. Then, mercury concentration data were used to determine the percent toxicity due to multiple toxicity endpoints. Mercury toxicity relationships for percent egg reproductive injury, percent larval reproductive injury, percent adult reproductive injury, percent juvenile survivorship injury, percent adult survivorship injury, and percent behavioral effects were entered into the spreadsheet.

5) Percent injury was combined with the number of fish in each age class for each time step to determine the total number of individuals affected. The results were kept separate for each toxicity endpoint and then were summed over time.

2.2.1.1 Fish Life History

A PVA was created to better understand the population dynamics of the Colorado pikeminnow in the San Juan River, including mercury toxicity and stocking (Miller 2015). The PVA model results for a single year (between 2016 – 2074) are the average of the 1,000 model runs for that year. A recovered Colorado pikeminnow population in the San Juan River ranged from 10,722 – 11,035 individual fish from 2016-2074.

Existing data were compiled to determine length-weight and length-age relationships in Colorado pikeminnow populations (Durst 2014; Valdez 2014) (**Figure 5**). Subsets of the data, such as the Green River, Colorado River, San Juan River, were also evaluated. Since data for the Colorado pikeminnow in the San Juan River are limited, data from tributaries were compared for similarity to San Juan River data and combined as necessary. A regression for Colorado pikeminnow total length by age was used to transform the PVA output data for the number of fish in each age class (Lusk, personal communication 2015). The result was the length of the fish in the age class, which was then used to determine fish mercury concentration for each age class.

Equation 1: y=980*(1-exp(-0.1134*(x-0.0750)))
L(t) = Linf*(1-exp(-K*(t-t0))),
where L(t) = length at time 't'
Linf = mean length of oldest fish
K = curvature parameter = how fast a fish approaches Linf
t = x = age of fish for determined length, in this case, the time step = 1 year
t_0 = initial condition parameter = time when the fish has no length

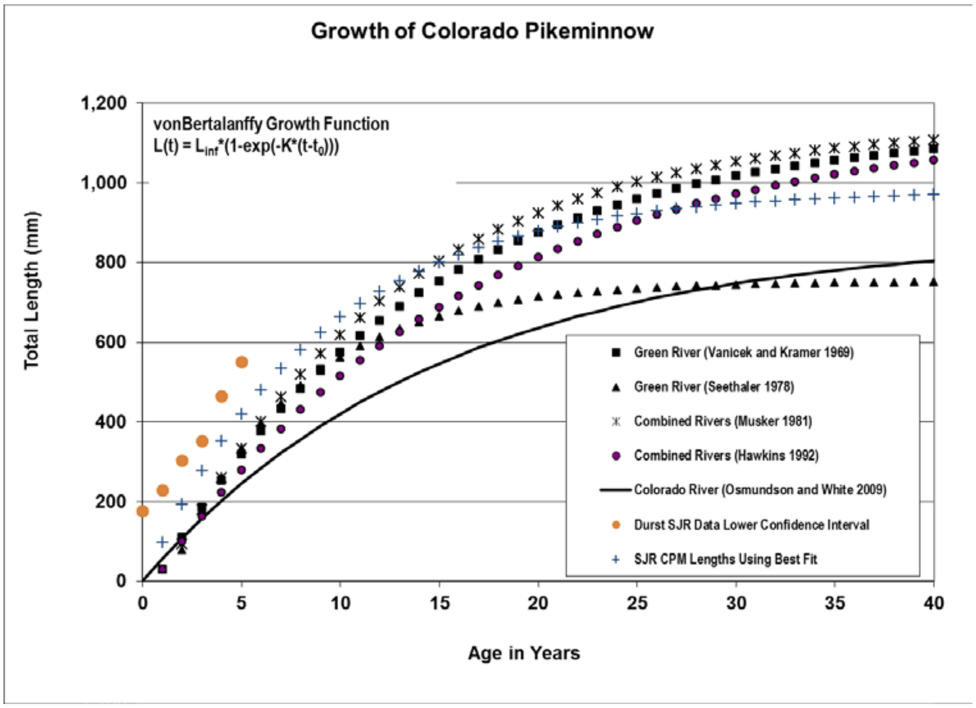


Figure 5 Growth Function for Colorado Pikeminnow Used in the FCPP BO ('SJR CPM Lengths Using Best Fit')

Length-mercury tissue data were also compiled (Osmundson and Skorupa 2011; Osmundson and Lusk 2011). Length-mercury tissue data were aggregated across the entire Upper Colorado River Basin, since the data from San Juan River were limited to fish lengths >400 mm (Equation 3) (**Figure 6**).

Equation 2: Hg body burden=-6.5+(5.6/(1+(10^((226.5-total length)*0.00415))))
See **Figure 6**

The concentration in fish determined in Equation 2 was the result of baseline conditions. The effects of FCPP operations were then paired with EPRI's Hg concentrations in fish for the same output year. The impacts due to FCPP Hg were determined by subtracting one EPRI deposition scenario from another. EPRI modeled many different FCPP emission scenarios (e.g., max emissions, plant closure, etc.), coupled with other coal-fired power plants in the Four Corner's area (Navajo Generating Station, San Juan Generating Station), other Hg sources in the nearby, other Hg sources in the US, and Other Cumulative Sources (aka 'China').

FCPP scenarios modeled by EPRI (2015):

- Medium China/APS 2042 Shutdown
- Low China deposition/APS 2016 Shutdown
- High China deposition/APS 2016 Shutdown
- APS never existed
- Low China deposition/APS 2042 shutdown
- High China deposition/APS 2042 shutdown

Four Corners Power Plant's contribution of mercury to Colorado pikeminnow in the San Juan River was calculated by subtracting the Hg in whole body fish from the 'High China/APS 2016 Shutdown' scenario from the 'High China/APS 2042 Shutdown' scenario.

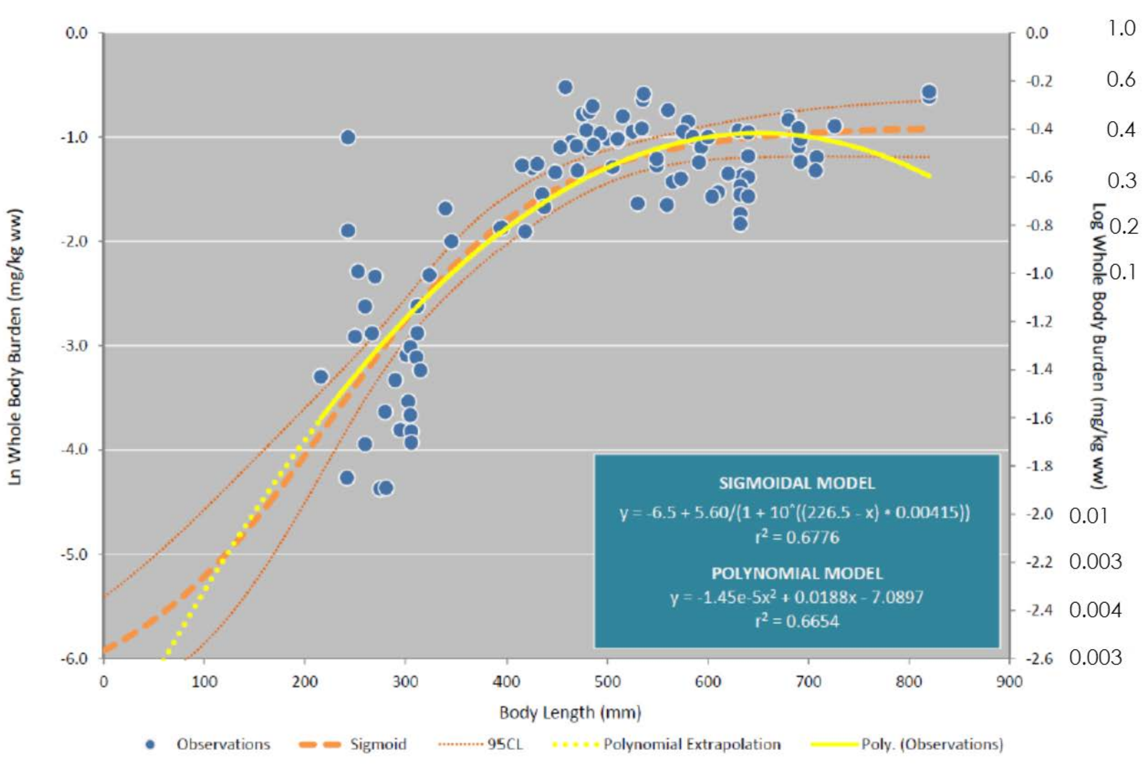


Figure 6 **Mercury Concentrations in Colorado Pikeminnow in the Upper Colorado River Basin Based on Total Body Length (Osmundson and Lusk 2011)**

2.2.1.2 Concentration in Eggs

Eggs were assigned 0.2 percent of adult female's mercury body burden and it was assumed that each reproducing Colorado pikeminnow female would spawn 62,133 eggs/year.

2.2.1.3 Mercury Toxicity

Mercury functional relationships were developed by Dillon et al. (2010) and refined by Shibata (2014) and used in the Colorado pikeminnow PVA (Miller 2014) (**Figure 7**). These relationships were used to estimate the number lethal and sublethal effects to eggs, larval fish (embryo), and adult fish in the FCPP BO (USFWS 2015).

Figure C5-1. *% Injury vs. Hg Functional Relationships Used in PVA Model*

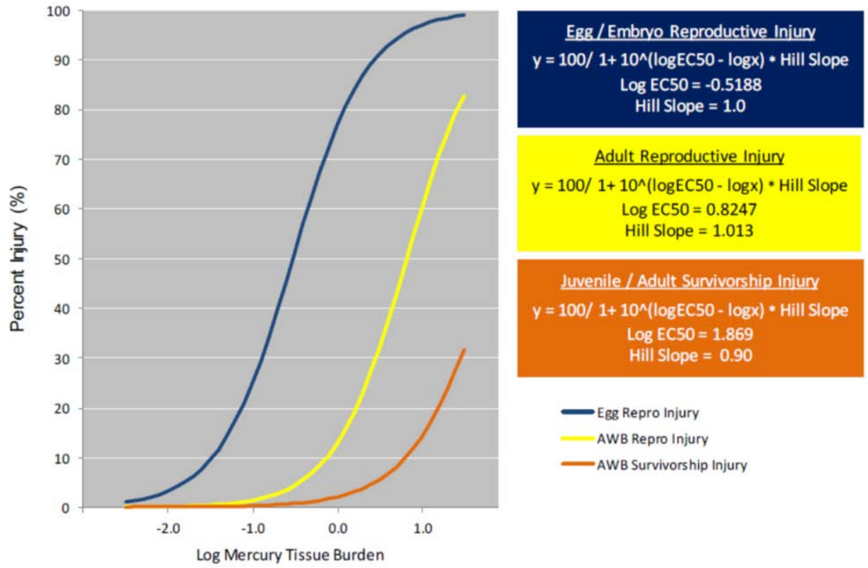


Figure 7 Refined Mercury Effect Curves for the Colorado Pikeminnow PVA

2.2.2 Selenium

2.2.2.1 Concentration in Fish

<u>Colorado Pikeminnow</u>

Selenium data from Osmundson and Lusk (2011) were used to determine the baseline selenium concentration (3.0 mg/kg dw).

<u>Razorback Sucker</u>

Selenium data from Osmundson and Lusk (2011) were used to determine the baseline selenium concentration (5.4 mg/kg dw).

2.2.2.2 Concentration in Eggs

<u>Colorado Pikeminnow</u>

Selenium transfer factors from studies and literature were compiled to determine selenium concentrations in eggs. Equations from Osmundson and Skorupa (2011), Osmundson et al. (2007), and Buhl and Hamilton (2000) were used. The results were averaged and then carried forward to determine egg survival.

Equation 1 (Osmundson and Skorupa (2011)): $y=e^{(0.7091*(\ln(\text{average fish tissue concentration})+0.6733)))}$

Equation 2 Roundtail chub pre-spawn (Osmundson et al. 2007) $y = =e^{((0.9384*(\mathrm{LN}(\text{ave fish tissue conc}))+0.815)}$

Equation 3 Roundtail chub - All (Osmundson et al. 2007) $y =e^{((1.3966*(\mathrm{LN}(\text{ave fish tissue conc}))-0.1945)}$

Razorback Sucker

Selenium transfer factors from studies and literature were compiled to determine selenium concentrations in eggs. Equation from Hamilton et al. (2001) was used:

Equation 4 (Hamilton et al. 2001): $=e^{((1.3*(\ln(\text{average fish tissue Se concentration})))-0.0575)}$

2.2.2.3 Egg Survival

Colorado Pikeminnow

Two equations were used to determine egg survival (Equations 5 and 6) (Lusk, personal communication 2015). Data from a variety of warmwater fish studies were used: Doroshov et al. (1992), Buhl and Hamilton (2000), Coyle et al. (1993), Hamilton et al. (2002, 2001), (**Figures 8** and **9**). The results from these equations were averaged and carried forward to determine the total number of eggs affected.

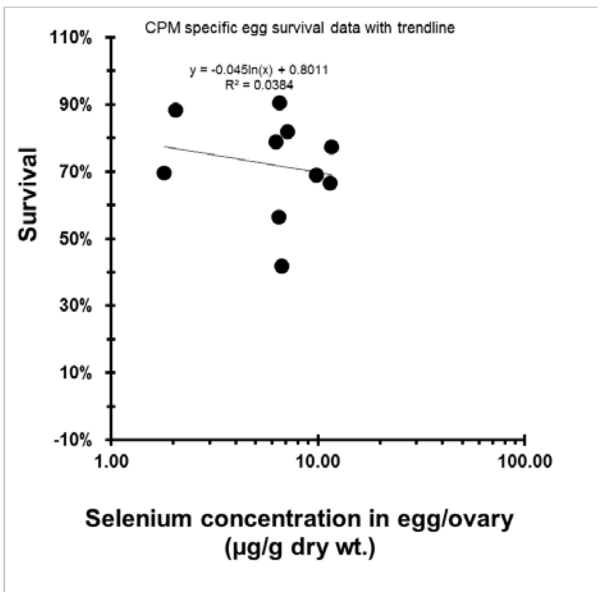


Figure 8 Colorado Pikeminnow Specific Egg Survival Regression Based on Selenium in Eggs

Equation 5: $y = -0.045*\ln(\text{egg concentration}) + 0.8011$

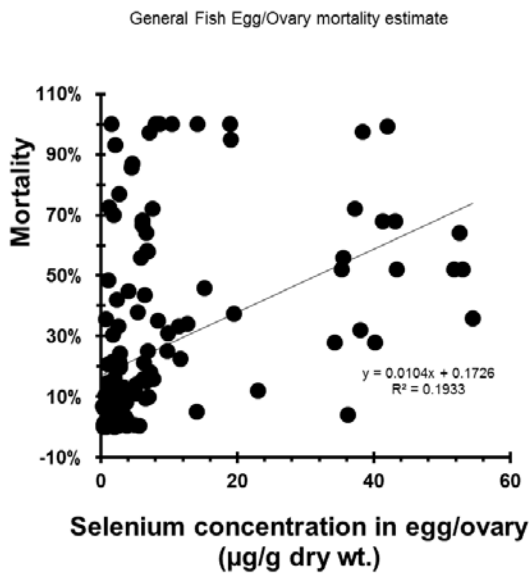


Figure 9 General Egg Survival Regression Based on Selenium in Eggs

Equation 6: y= 0.0104* (egg concentration) + 0.1726

<u>Razorback Sucker</u>

Enough data for razorback sucker egg survival were available to determine percent survival based on selenium in razorback sucker eggs and ovaries (Equation 7, J Lusk, personal communication 2016, using data from Hamilton et al. (2005a,b,c, 2002, 2001) (**Figure 10**).

Equation 7: Razorback sucker specific egg survival (y) =-0.042*(egg Se concentration)+0.6993

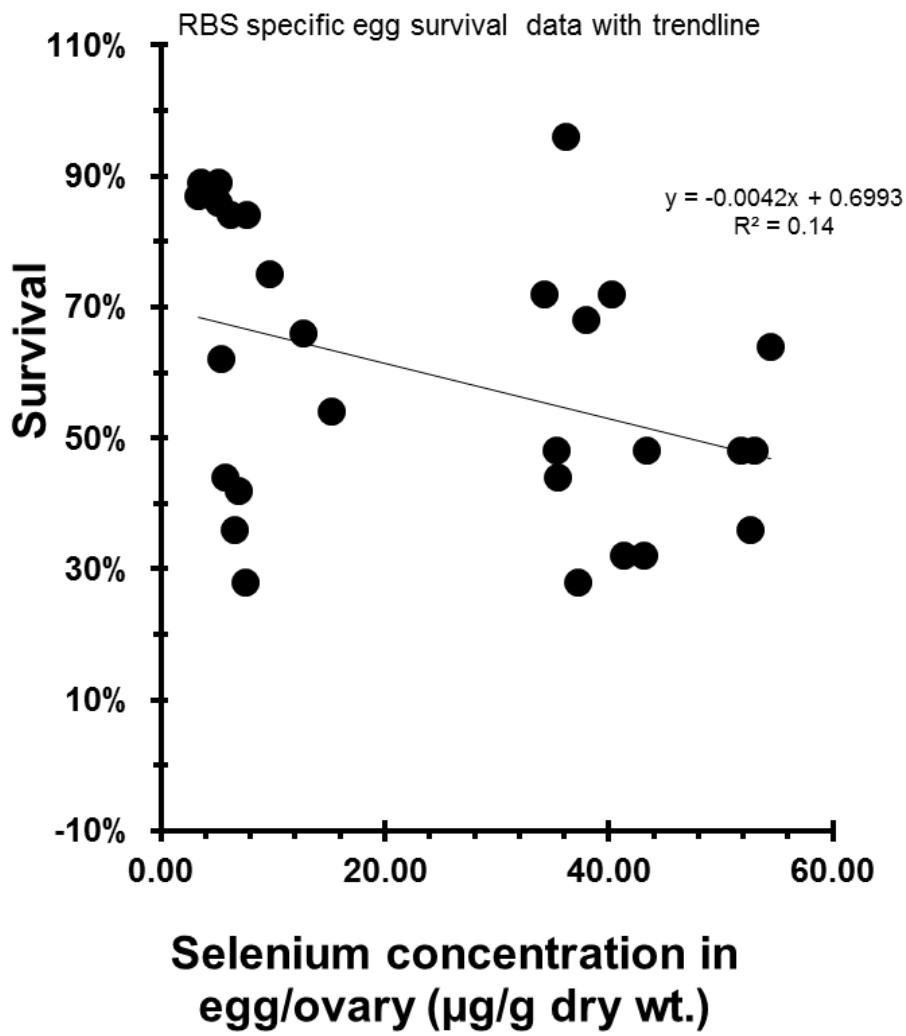


Figure 10 Razorback Sucker Specific Egg Survival Based on Selenium Concentration in Eggs

2.2.2.4 Larval Fish

The selenium effects on larval fish are based on their dietary exposure. The selenium concentration in a diet of 25 percent plants and 75 percent invertebrates was used to estimate the survival of larval razorback suckers and Colorado pikeminnow. The upper confidence interval of mean selenium in plants and invertebrates was calculated from data in the FCPP BA (AECOM 2014, Appendix A, Table 3 and 4).

A biphasic relationship between dietary selenium and larval razorback sucker survival was developed based on Beckon et al. (2008; J. Lusk, personal communication 2015) using larval fish data from Beyers and Sodergren (1999), Hamilton et al. (2001a,b, 1996) (**Figure 11**). This same equation was used for Colorado pikeminnow.

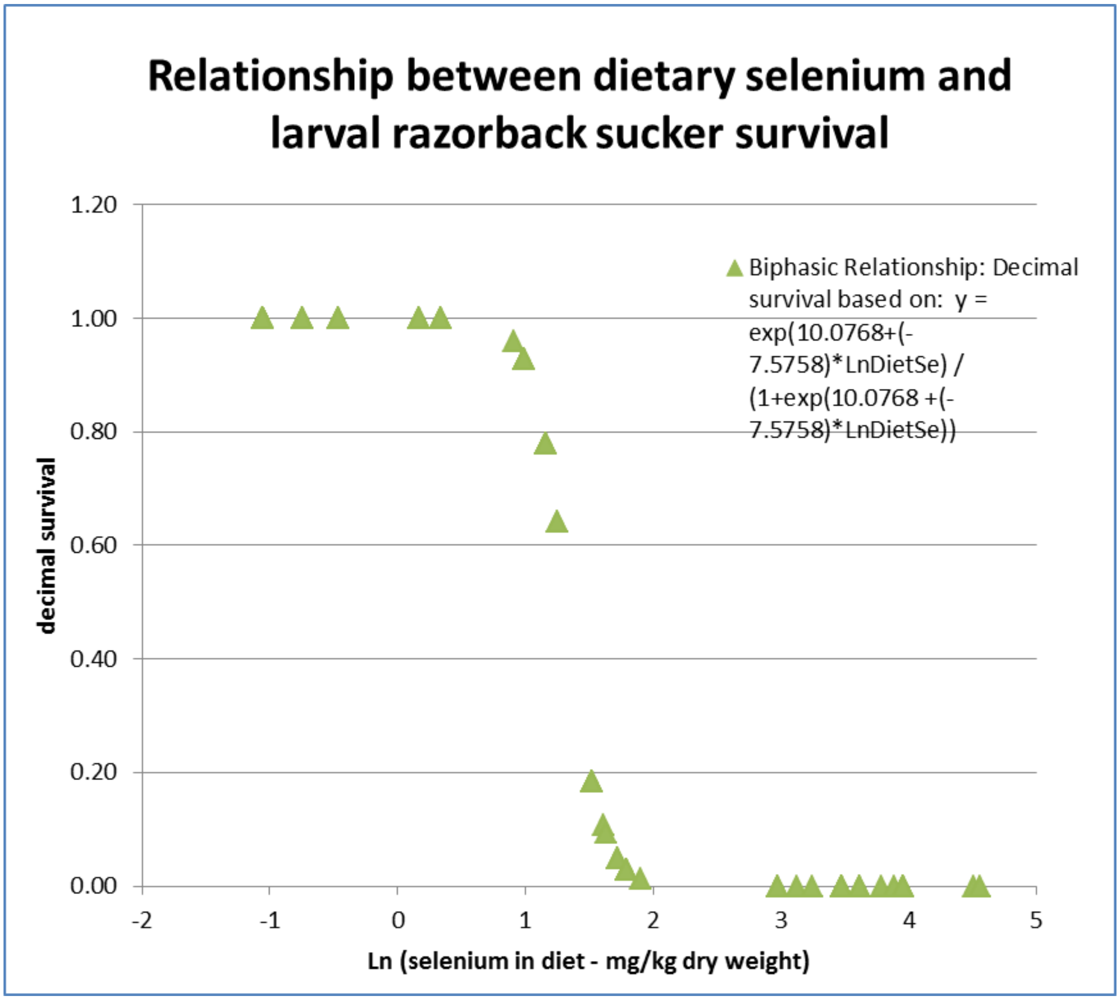


Figure 11 Biphasic relationship developed by Lusk (personal communication 2015) based on a model by Beckon et al. (2008) and data from several studies (Beyers and Sodergren 1999, Hamilton et al. 2001a,b, 1999).

2.2.2.5 Number of Individuals Affected

The amount of impact due to emissions and deposition of selenium in FCPP and NGS on the San Juan River are essentially the same. The FCPP would contribute 0.43 percent of the selenium from future operations of the plant when compared to baseline selenium (EPRI 2015, page 10-9). For the NGS, EPRI estimated that NGS' maximum contribution would be 0.44 percent (EPRI 2016, pages 10-17 and 18). At this time, the best estimate of the amount of injury for Colorado pikeminnow and razorback sucker in the San Juan River is to use the same values used in the FCPP Final BO.

To determine mortality due to baseline selenium concentrations, percent mortality was determined using 100 minus percent survival. The percent selenium due to NGS peaks in 2038 at 44 percent (Figure 10-6, EPRI 2016).

3.0 References

AECOM. 2014. Biological Assessment for the Four Corners Power Plant SCR Retrofit Project. AECOM, Fort Collins, Colorado.

Beckvar, N., T. M. Dillon, and L. B. Read. 2005. Approaches for Linking Whole-body Fish Tissue Residues of Mercury or DDT to Biological Effects Thresholds. Environmental Toxicology and Chemistry 24(8):2094-2105.

Beckon, W. N., C. Parkins, A. Maximovich, and A. V. Beckon. 2008. A General Approach to Modeling Biphasic Relationships. Environmental Science & Technology 42: 1308-1314.

Beyers, D. W. and C. Sodergren. 1999. Assessment and Prediction of Effects of Selenium Exposure to Larval Razorback Sucker. Larval Fish Laboratory, Ft. Collins, Colorado. Contribution 107. Final Report to Recovery Implementation Program for the Endangered Fish Species in the Upper Colorado River Basin.

Buhl, K. J. and S. J. Hamilton. 2000. The Chronic Toxicity of Dietary and Waterborne Selenium to Adult Colorado Pikeminnow (*Ptychocheilus lucius*) in a Water Quality Simulating that in the San Juan River. Final Report to the San Juan River Basin Recovery Implementation Program. 112 pp.

Coyle, J. J., D. R. Buckler, C. G. Ingersoll, J. F. Fairchild, and T. W. May. 1993. Effect of Dietary Selenium on the Reproductive Success of Bluegills (*Lepomis macrochirus*). Environmental Toxicology and Chemistry 12:551-565.

Dillon, T., N. Beckvar, and J. Kern. 2010. Residue-based Mercury Dose-Response in Fish: An Analysis Using Lethality-equivalent Test Endpoints. Environmental Toxicology and Chemistry 29:2559-2565.

Doroshov, S., J. V. Eenennaam, C. Alexander, E. Hallen, H. Bailey, K. Kroll, and C. Restrepo. 1992. Development of Water Quality Criteria for Resident Aquatic Species of the San Joaquin River. Draft Final Report to the California State Water Resources Control Board for Contract No. 7-191-250-0. Department of Animal Science, University of California, Davis.

Durst, S. 2014. Appendix D: Preliminary Vortex Input Data Summary In: the PVA for the Colorado Pikeminnow by P Miller. 12 pp.

Electric Power Research Institute (EPRI). 2016. A Case Study Assessment of Trace Metal Atmospheric Emissions and Their Aquatic Impacts in the San Juan River Basin. Phase 2: Navajo Generating Station. 3002006244: R. Goldstein and L. Levin. Final Report. April 2016.

Electric Power Research Institute (EPRI). 2015. A Case Study Assessment of Trace Metal Atmospheric Emissions and Their Aquatic Impacts in the San Juan River basin. Phase 1: Four Corners Power Plant. Palo Alto, CA. 3002006263. 436 pp.

Environmental Power Research Institute (EPRI). 2014. A Case Study Assessment of Trace Metal Atmospheric Emissions and Their Aquatic Impacts in the San Juan River Basin. Palo Alto, California.

Hamilton, S. J., K. M. Holley, K. J. Buhl, F. A. Bullard, L. K. Weston, and S. F. McDonald. 2005a. Selenium Impacts on Razorback Sucker, Colorado River, Colorado. I. Adults. Ecotoxicology and Environmental Safety 61:7-31.

Hamilton, S. J., K. M. Holley, K. J. Buhl, F. A. Bullard, L. K. Weston, and S. F. McDonald. 2005b. Selenium Impacts on Razorback Sucker, Colorado River, Colorado. II. Eggs. Ecotoxicology and Environmental Safety 61:32-43.

Hamilton, S. J., K. M. Holley, K. J. Buhl, F. A. Bullard, L. K. Weston, and S. F. McDonald. 2005c. Selenium Impacts on Razorback Sucker, Colorado River, Colorado. III. Larvae. Ecotoxicology and Environmental Safety 61:168-189.

Hamilton S. J., K. M. Holley, and K. J. Buhl. 2002. Hazard Assessment of Selenium to Endangered Razorback Suckers (*Xyrauchen texanus*). Science of the Total Environment 291:111-121.

Hamilton, S.J., K. M. Holley, K. J. Buhl, F. A. Bullard, L. K. Weston, and S. F. McDonald. 2001a. The Evaluation of Contaminant Impacts on Razorback Sucker Held in Flooded Bottomland Sites near Grand Junction, Colorado – 1996. Final Report. U.S. Geological Survey, Yankton, South Dakota. 302 pp.

Hamilton, S. J., K. M. Holley, K. J. Buhl, F. A. Bullard, L. K. Weston, and S. F. McDonald. 2001b. The Evaluation of Contaminant Impacts on Razorback Sucker Held in Flooded Bottomland Sites Near Grand Junction, Colorado – 1997. Final Report. U.S. Geological Survey, Yankton, South Dakota. 229 pp.

Hamilton, S. J., K. J. Buhl, F. A. Bullard, and S. F. McDonald. 1996. Evaluation of Toxicity to Larval Razorback Sucker of Selenium-Laden Food Organisms from Ouray NWR on the Green River, Utah. Final Report to U.S. Fish and Wildlife Service, Denver. National Biological Service, Midwest Science Center, Ecotoxicology Research Station, Yankton, South Dakota.

Kepner, W. G. 1988. Memorandum from U.S. Fish and Wildlife Service, Ecological Services. Analytical Request – Little Colorado River with Tracking Form for Contaminant Analysis of Biological and Bottom Sediment Samples from the Little Colorado River in Grand Canyon National Park. Phoenix, Arizona. June 16, 1988.

Lusk, J. 2016. Personal communication regarding biphasic selenium model developed for razorback sucker survival due to dietary selenium exposure for the Four Corners Power Plant Biological Opinion, between U.S. Fish and Wildlife Service (USFWS), New Mexico Ecological Services Field Office, and C. Marr, USFWS, Arizona Ecological Services Field Office.

Miller, P. S. 2014. A Population Viability Analysis for the Colorado Pikeminnow (*Ptychocheilus lucius*) in the San Juan River. 175 pp.

Osmundson, B. and J. Lusk. 2011. Interim Report - Field Assessment of Mercury Exposure to Colorado Pikeminnow within Designated Critical Habitat. U.S. Fish and Wildlife Service, Region 6, Environmental Contaminants Program, Off-Refuge Investigations Report, Grand Junction, Colorado.

Osmundson, B. C. and J. Skorupa. 2011. Selenium in Fish Tissue: Prediction Equations for Conversion between Whole Body, Muscle, and Eggs. Final Report. EC Investigation. Grand Junction, Colorado. 43 pp.

Osmundson, B. C., T. May, J. Skorupa, and R. Krueger. 2007. Selenium in Fish Tissue: Prediction Equations for Conversion between Whole Body, Muscle, and Eggs. Poster presentation at the 2007 Annual Meeting of the Society of Environmental Toxicology and Chemistry, Milwaukee, Wisconsin, USA.

Ramboll Environ. 2016. DRAFT FINAL NGS Gap Region Ecological Risk Assessment Environmental Impact Statement Final Report for the Navajo Generating Station. March 2016.

Shibata, M. 2014. Appendix C: Mercury Functional Relationship In*:* the PVA for the Colorado Pikeminnow by P. Miller. 30 pp.

U.S. Fish and Wildlife Service (USFWS). 2015. Biological Opinion for Four Corners Power Plant and Navajo Energy Project. USFWS, Albuquerque, New Mexico.

Valdez, R. 2014. Appendix B: Colorado pikeminnow Demographic Data Summary In: The PVA for the Colorado Pikeminnow by P. Miller. 66 pp.

This page intentionally left blank

Appendix 3.13-B

ERA Results for the Proposed Action in Combination with Baseline and Other Cumulative Emissions

This page intentionally left blank

Table 1A Mercury and Selenium Tissue and HQ Values for Bonytail Surrogate (Rainbow Trout), NGS 3-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, Northeast Gap Region

Metal	CBR (mg/kg ww)	Baseline		3-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	3-Unit %
Mercury										
Maximum	0.2	0.12	0.6	0.0006	0.003	0.247	1	0.3656	2	0.16%
Refined	0.2	0.094	0.5	0.0003	0.002	0.104	0.5	0.1984	1	0.15%
Selenium										
Maximum	2	*0.84*	0.4	0.0001	0.00005	0.0000303	0.00002	0.8351	0.4	0.01%
Refined	2	*0.33*	0.2	0.00007	0.00003	0.00000515	0.000003	0.3281	0.2	0.02%

Table 1B Mercury and Selenium Tissue and HQ Values for Bonytail Surrogate (Rainbow Trout), NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, Northeast Gap Region

Metal	CBR (mg/kg ww)	Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Mercury										
Maximum	0.2	0.12	0.6	0.0004	0.002	0.247	1	0.3654	2	0.11%
Refined	0.2	0.094	0.5	0.0002	0.001	0.104	0.5	0.1984	1	0.10%
Selenium										
Maximum	2	*0.84*	0.4	0.00007	0.00004	0.0000303	0.00002	0.8351	0.4	0.01%
Refined	2	*0.33*	0.2	0.00005	0.00002	0.00000515	0.000003	0.3281	0.2	0.01%

Table 2A Mercury and Selenium Tissue and HQ Values for Colorado Pikeminnow Surrogate (Largemouth Bass), NGS 3-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, Northeast Gap Region

		Baseline		3-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
Metal	CBR (mg/kg ww)	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	3-Unit %
Mercury										
Maximum	0.2	0.12	0.6	0.00058	0.003	0.247	1	0.3636	2	0.16%
Refined	0.2	0.12	0.6	0.00031	0.002	0.104	1	0.2203	1	0.14%
Selenium										
Maximum	2	*0.84*	0.4	0.00011	0.00005	0.0000303	0.00002	0.8351	0.4	0.01%
Refined	2	*0.33*	0.2	0.000068	0.00003	0.00000515	0.000003	0.3281	0.2	0.02%

Table 2B Mercury and Selenium Tissue and HQ Values for Colorado Pikeminnow Surrogate (Largemouth Bass), NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, Northeast Gap Region

		Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
Metal	CBR (mg/kg ww)	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Mercury										
Maximum	0.2	0.12	0.6	0.00039	0.002	0.247	1	0.3634	2	0.11%
Refined	0.2	0.12	0.6	0.00021	0.001	0.104	1	0.2202	1	0.10%
Selenium										
Maximum	2	*0.84*	0.4	0.000073	0.00004	0.0000303	0.00002	0.8351	0.4	0.01%
Refined	2	*0.33*	0.2	0.000046	0.00002	0.00000515	0.000003	0.3281	0.2	0.01%

Table 3A Arsenic, Mercury, and Selenium Tissue and HQ Values for Colorado Pikeminnow Tissue, NGS 3-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		3-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	3-Unit %
Arsenic*										
Maximum	5.5	0.37	0.07	0.00010	0.00002	0.013	0.002	0.3801	0.1	0.03%
Refined	5.5	0.37	0.07	0.000086	0.00002	0.0114	0.002	0.3785	0.1	0.02%
Mercury*										
Maximum	0.2	0.25	1	0.00029	0.001	0.12	0.6	0.3703	2	0.08%
Refined	0.2	0.11	0.5	0.00018	0.0008	0.103	0.5	0.2132	1	0.08%
Selenium										
Maximum	2	1.1	0.5	0.00026	0.0001	0.04	0.02	1.1403	0.6	0.02%
Refined	2	0.78	0.4	0.00024	0.0001	0.0366	0.02	0.8168	0.4	0.03%

Table 3B Arsenic, Mercury, and Selenium Tissue and HQ Values for Colorado Pikeminnow Tissue, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Arsenic*										
Maximum	5.5	0.37	0.07	<0.00010	<0.00002	0.013	0.002	<0.3801	<0.1	<0.03%
Refined	5.5	0.37	0.07	<0.000086	<0.00002	0.0114	0.002	<0.3785	<0.1	<0.02%

Table 3B Arsenic, Mercury, and Selenium Tissue and HQ Values for Colorado Pikeminnow Tissue, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Mercury*										
Maximum	0.2	0.25	1	<0.00029	<0.001	0.12	0.6	<0.3703	<2	<0.08%
Refined	0.2	0.11	0.5	<0.00018	<0.0008	0.103	0.5	<0.2132	<1	<0.08%
Selenium										
Maximum	2	1.1	0.5	0.00018	0.00009	0.04	0.02	1.1402	0.6	0.02%
Refined	2	0.78	0.4	0.00016	0.00008	0.0366	0.02	0.8168	0.4	0.02%

Table 4A Arsenic, Mercury, and Selenium Tissue and HQ Values for Colorado Pikeminnow Surrogate Tissue, NGS 3-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		3-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	3-Unit %
Arsenic*										
Maximum	5.5	0.37	0.07	0.00010	0.00002	0.013	0.002	0.3801	0.1	0.03%
Refined	5.5	0.37	0.07	0.000086	0.00002	0.0114	0.002	0.3785	0.1	0.02%
Mercury*										
Maximum	0.2	0.25	2	0.00029	0.001	0.12	0.6	0.6053	3	0.05%
Refined	0.2	0.11	1	0.00018	0.0009	0.103	0.5	0.3092	2	0.06%
Selenium										
Maximum	2	1.3	0.7	0.00026	0.0001	0.040	0.02	1.3703	0.7	0.02%
Refined	2	1.3	0.7	0.00024	0.0001	0.0366	0.02	1.3368	0.7	0.02%

Table 4B Arsenic, Mercury, and Selenium Tissue and HQ Values for Colorado Pikeminnow SurrogateTissue, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Arsenic*										
Maximum	5.5	0.37	0.07	<0.00010	<0.00002	0.013	0.002	<0.3801	<0.1	<0.03%
Refined	5.5	0.37	0.07	<0.000086	<0.00002	0.0114	0.002	<0.3785	<0.1	<0.02%

Table 4B Arsenic, Mercury, and Selenium Tissue and HQ Values for Colorado Pikeminnow SurrogateTissue, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

		Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
Metal	CBR (mg/kg ww)	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Mercury*										
Maximum	0.2	0.25	1	<0.00029	<0.001	0.12	0.6	<0.6053	<3	<0.05%
Refined	0.2	0.11	0.5	<0.00018	<0.0009	0.103	0.5	<0.3092	<2	<0.06%
Selenium										
Maximum	2	1.3	0.7	0.00018	0.00009	0.040	0.02	1.3702	0.7	0.016%
Refined	2	1.3	0.7	0.00016	0.00008	0.0366	0.02	1.3368	0.7	0.019%

Table 5A Mercury and Selenium Tissue and HQ Values for Humpback Chub, NGS 3-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, Southwest Gap Region

Metal	CBR (mg/kg ww)	Baseline		3-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	3-Unit %
Mercury										
Maximum	0.2	0.17	0.8	0.0010	0.005	0.708	4	0.8790	4	0.12%
Refined	0.2	0.15	0.7	0.00056	0.003	0.396	2	0.5466	3	0.10%
Selenium										
Maximum	2	0.74	0.4	0.00082	0.0004	0.00000472	0.000002	0.7408	0.4	0.11%
Refined	2	0.73	0.4	0.00052	0.0003	0.00000169	0.000001	0.7255	0.4	0.07%

Table 5B Mercury and Selenium Tissue and HQ Values for Humpback Chub, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, Southwest Gap Region

Metal	CBR (mg/kg ww)	Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Mercury										
Maximum	0.2	0.17	0.8	0.00070	0.003	0.708	4	0.8787	4	0.08%
Refined	0.2	0.15	0.7	0.00038	0.002	0.396	2	0.5464	3	0.07%
Selenium										
Maximum	2	0.74	0.4	0.00055	0.0003	0.00000472	0.000002	0.7406	0.4	0.075%
Refined	2	0.73	0.4	0.00035	0.0002	0.00000169	0.000001	0.7254	0.4	0.048%

Table 6A Mercury and Selenium Tissue and HQ Values for Razorback Sucker, NGS 3-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, Southwest Gap Region

Metal	CBR (mg/kg ww)	Baseline		3-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	3-Unit %
Mercury										
Flannelmouth sucker										
Maximum	0.2	0.98	5	0.0010	0.005	0.708	4	1.6890	8	0.06%
Refined	0.2	0.67	3	0.00056	0.003	0.396	2	1.0666	5	0.05%
Bluehead sucker										
Maximum	0.2	0.21	1	0.0010	0.005	0.708	4	0.9190	5	0.08%
Refined	0.2	0.16	0.8	0.00056	0.003	0.396	2	0.5566	3	0.07%
Selenium										
Flannelmouth sucker										
Maximum	2	2.9	1	0.00082	0.0004	0.00000472	0.000002	2.8808	1	0.03%
Refined	2	2.5	1	0.00052	0.0003	0.00000169	0.000001	2.4505	1	0.02%
Bluehead sucker										
Maximum	2	1.5	0.8	0.00082	0.0004	0.00000472	0.000002	1.5008	0.8	0.06%
Refined	2	1.3	0.7	0.00052	0.0003	0.00000169	0.000001	1.3005	0.7	0.04%

Table 6B Mercury and Selenium Tissue and HQ Values for Razorback Sucker, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, Southwest Gap Region

Metal	CBR (mg/kg ww)	Baseline Conc. (mg/kg ww)	Baseline HQ	2-Unit Operation Conc. (mg/kg ww)	2-Unit Operation HQ	Other Cumulative Sources Conc. (mg/kg ww)	Other Cumulative Sources HQ	Total Cumulative Conc. (mg/kg ww)	Total Cumulative HQ	NGS Contribution to Total Cumulative 2-Unit %
Mercury										
Flannelmouth sucker										
Maximum	0.2	0.98	5	0.00070	0.003	0.708	4	1.6887	8	0.04%
Refined	0.2	0.67	3	0.00038	0.002	0.396	2	1.0664	5	0.04%
Bluehead sucker										
Maximum	0.2	0.21	1	0.00070	0.003	0.708	4	0.9187	5	0.08%
Refined	0.2	0.16	0.8	0.00038	0.002	0.396	2	0.5564	3	0.07%
Selenium										
Flannelmouth sucker										
Maximum	2	2.9	1	0.00055	0.0003	0.00000472	0.000002	2.8806	1	0.02%
Refined	2	2.5	1	0.00035	0.0002	0.00000169	0.000001	2.4504	1	0.01%
Bluehead sucker										
Maximum	2	1.5	0.8	0.00055	0.0003	0.00000472	0.000002	1.5006	0.8	0.04%
Refined	2	1.3	0.7	0.00035	0.0002	0.00000169	0.000001	1.3004	0.7	0.03%

Table 7A Arsenic, Mercury, and Selenium Tissue and HQ Values for Razorback Sucker Surrogates, NGS 3-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

		Baseline		3-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
Metal	CBR (mg/kg ww)	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	3-Unit %
Arsenic*										
Flannelmouth sucker										
Maximum	5.5	0.32	0.06	0.00010	0.00002	0.011	<0.1	0.3311	0.06	0.03%
Refined	5.5	0.10	0.02	0.000086	0.00002	0.0114	<0.1	0.1135	0.02	0.08%
Bluehead sucker										
Maximum	5.5	0.36	0.06	0.00010	0.00002	0.010	<0.1	0.3701	0.07	0.03%
Refined	5.5	0.2	0.04	0.000086	0.00002	0.0104	<0.1	0.2105	0.04	0.04%
Mercury*										
Flannelmouth sucker										
Maximum	0.2	0.27	1	0.00012	0.0006	0.05	0.3	0.3201	2	0.04%
Refined	0.2	0.11	0.6	0.000080	0.0004	0.0475	0.2	0.1576	0.8	0.05%
Bluehead sucker										
Maximum	0.2	0.096	0.5	0.00012	0.0006	0.051	0.3	0.1471	0.7	0.08%
Refined	0.2	0.048	0.2	0.000080	0.0004	0.0475	0.2	0.0960	0.5	0.08%
Selenium										
Flannelmouth sucker										
Maximum	2	2.5	1	0.00026	0.0001	0.04	<0.1	2.5403	1	0.01%
Refined	2	0.81	0.4	0.00024	0.0001	0.0366	<0.1	0.8468	0.4	0.03%
Bluehead sucker										
Maximum	2	1.6	0.8	0.00026	0.0001	0.04	<0.1	1.6803	0.8	0.02%
Refined	2	0.61	0.3	0.00024	0.0001	0.0366	<0.1	0.6468	0.3	0.04%

Table 7B Arsenic, Mercury, and Selenium Tissue and HQ Values for Razorback Sucker Surrogates, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Arsenic*										
Flannelmouth sucker										
Maximum	5.5	0.32	0.06	<0.00010	<0.00002	0.011	<0.1	<0.3311	<0.060	<0.03%
Refined	5.5	0.10	0.02	<0.000086	<0.00002	0.0114	<0.1	<0.1135	<0.021	<0.08%
Bluehead sucker										
Maximum	5.5	0.36	0.06	<0.00010	<0.00002	0.010	<0.1	<0.3701	<0.067	<0.03%
Refined	5.5	0.2	0.04	<0.00008	<0.00001	0.0104	<0.1	0.2105	0.038	<0.04%
Mercury*										
Flannelmouth sucker										
Maximum	0.2	0.27	1	<0.00012	<0.0005	0.05	0.3	<0.3201	<1.601	<0.04%
Refined	0.2	0.11	0.6	<0.0008	<0.0004	0.0475	0.2	<0.1576	<0.788	<0.05%
Bluehead sucker										
Maximum	0.2	0.096	0.5	<0.00012	<0.0006	0.051	0.3	<0.1471	<0.736	<0.08%
Refined	0.2	0.048	0.2	<0.0001	<0.0004	0.0475	0.2	<0.0960	<0.480	<0.08%
Selenium										
Flannelmouth sucker										
Maximum	2	2.5	1	0.00018	0.00009	0.04	<0.1	2.5402	1	0.01%
Refined	2	0.81	0.4	0.00016	0.00008	0.0366	<0.1	0.8468	0.4	0.02%
Bluehead sucker										
Maximum	2	1.6	0.8	0.00018	0.0001	0.04	<0.1	1.6802	0.8	0.01%
Refined	2	0.61	0.3	0.00016	0.0001	0.0366	<0.1	0.6468	0.3	0.02%

Table 8A Arsenic, Mercury, and Selenium Tissue and HQ Values for Razorback Sucker, NGS 3-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		3-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	3-Unit %
Arsenic*										
Maximum	5.5	0.34	0.06	0.00010	0.00002	0.013	<0.1	0.3531	0.1	0.03%
Refined	5.5	0.22	0.04	0.000086	0.00002	0.0114	<0.1	0.2315	0.04	0.04%
Mercury*										
Maximum	0.2	0.15	0.7	0.00012	0.0005	0.051	0.3	0.2011	1	0.06%
Refined	0.2	0.09	0.4	0.00008	0.0004	0.0475	0.2	0.1376	0.7	0.06%
Selenium										
Maximum	2	2.3	1	0.00026	0.0001	0.04	<0.1	2.3403	1	0.01%
Refined	2	0.95	0.5	0.00024	0.0001	0.036	<0.1	0.9862	0.5	0.02%

Table 8B Arsenic, Mercury, and Selenium Tissue and HQ Values for Razorback Sucker, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Arsenic*										
Maximum	5.5	0.34	0.06	<0.00010	<0.00002	0.013	<0.1	<0.3531	<0.1	<0.03%
Refined	5.5	0.22	0.04	<0.000088	<0.00002	0.0114	<0.1	<0.2315	<0.04	<0.04%

Table 8B Arsenic, Mercury, and Selenium Tissue and HQ Values for Razorback Sucker, NGS 2-Unit Operations with Baseline, Other Cumulative Sources, and Total Cumulative Sources, San Juan River

Metal	CBR (mg/kg ww)	Baseline		2-Unit Operation		Other Cumulative Sources		Total Cumulative		NGS Contribution to Total Cumulative
		Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	Conc. (mg/kg ww)	HQ	2-Unit %
Mercury*										
Maximum	0.2	0.15	0.7	<0.00012	<0.0005	0.051	0.3	<0.2011	<1	<0.06%
Refined	0.2	0.09	0.4	<0.00080	<0.0004	0.0475	0.2	<0.1376	<0.7	<0.06%
Selenium										
Maximum	2	2.3	1	0.00018	0.00009	0.04	<0.1	2.3402	1	0.01%
Refined	2	0.95	0.5	0.00016	0.00008	0.036	<0.1	0.9862	0.5	0.02%

This page intentionally left blank

Appendix 4A

Conservation Measures

This page intentionally left blank

This appendix is a component of the Biological Assessment associated with this EIS

This page intentionally left blank

Acronyms and Abbreviations

µg/m^2	micrograms per square meter
°C	degrees Celsius
°F	degrees Fahrenheit
AGFD	Arizona Game and Fish Department
APS	Arizona Public Service
BA	Biological Assessment
BLM	Bureau of Land Management
BM&LP Railroad	Black Mesa & Lake Powell Railroad
BMP	best management practice
BO	Biological Opinion
EIS	Environmental Impact Statement
ESA	Endangered Species Act of 1973, as amended
KMC	Kayenta Mine Complex
NEPA	National Environmental Policy Act
NGS	Navajo Generating Station
Navajo NHP	Navajo Natural Heritage Program
NPS	National Park Service
NV Energy	Nevada Energy
O&M	Operations and Maintenance
PIT	Passive Integrated Transponder
Project	Proposed Action
Reclamation	U.S. Bureau of Reclamation
RMP	Resource Management Plan
ROW	right-of-way
SRP	Salt River Project Agricultural Improvement and Power District
STS	Southern Transmission System
U.S.	United States
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
WTS	Western Transmission System

This page intentionally left blank

Contents

1.0 Conservation Measures 4A-7
1.1 Existing Impact Avoidance and Minimization Measures 4A-7
1.2 General Conservation Measures 4A-7
1.3 Species-Specific Conservation Measures 4A-14
1.3.1 Fish Species 4A-14
1.3.1.1 Colorado Pikeminnow, Humpback Chub, and Razorback Sucker 4A-15
1.3.1.2 Loach Minnow, Spikedace, Gila Topminnow, and Gila Chub 4A-20
1.3.2 Avian Species 4A-21
1.3.3 Reptile Species 4A-21

List of Tables

Table 1 Impact Avoidance and Minimization Measures Directly and Indirectly Applicable to Conservation of Federally Listed, Proposed, and Candidate Species in the Action Area 4A-8

This page intentionally left blank

1.0 Conservation Measures

This chapter summarizes and/or incorporates by reference existing and proposed measures for impact avoidance and minimization that pertain, either directly or indirectly, to federally listed species. These conservation measures are part of the Proposed Action. The Bureau of Land Management (BLM), Kaibab National Forest, Prescott National Forest, Grand Canyon National Park, and Glen Canyon National Recreation Area are cooperating agencies on this project and their existing conservation measures have been incorporated and are applicable. For the purposes of this Biological Assessment (BA), applicant-committed mitigation measures contained in the Navajo Project Operation and Maintenance Plan (Salt River Project Agricultural Improvement and Power District [SRP] 2016) are considered conservation measures. These general (i.e., non-species specific) conservation measures are summarized in Section 1.2, **Table 1**, below. Species-specific conservation measures contained in the Navajo Project Operation and Maintenance Plan and other species-specific measures that have been developed to avoid, minimize, or compensate for adverse effects to listed species are described in Section 1.3 below.

1.1 Existing Impact Avoidance and Minimization Measures

Existing measures, including the BLM Resource Management Plan (RMP) surface use and timing restrictions and U.S. Forest Service Land and Resource Management Plan (or "Forest Plan") standards and guidelines, require that transmission line operations and maintenance (O&M) activities avoid and minimize impacts to federally listed species and their habitats. BLM RMPs applicable to the Western Transmission System (WTS) include those for the Grand Staircase – Escalante National Monument, Kanab, Arizona Strip, St. George, Ely, and Las Vegas Planning Areas. For the Southern Transmission System (STS), applicable RMPs include those for the Bradshaw-Harquahala and the Agua-Fria National Monument Planning Areas and the Forest Plans for the Kaibab and Prescott National Forests. Applicable measures are incorporated by reference to these plans and not reproduced herein. Note that the general and species-specific measures described in Sections 1.2 and 1.3, below, are more comprehensive than those contained in the above BLM RMPs and U.S. Forest Service Forest Plans.

1.2 General Conservation Measures

Table 1 lists applicable conservation measures from the Navajo Project Operation and Maintenance Plan (SRP 2016) and additional general conservation measures developed during the National Environmental Policy Act process and Endangered Species Act (ESA) Section 7 consultation process for the project. Implementation of these measures would avoid or minimize adverse effects to multiple species. The assessments of effects for individual species contained in Chapter 6.0 of this BA identify, which of the following measures apply to a given species. These measures, along with the species-specific conservation measures described below, have been accounted for in evaluating impacts to individual species as well as in the determination of project effects on these species.

Table 1 Impact Avoidance and Minimization Measures Directly and Indirectly Applicable to Conservation of Federally Listed, Proposed, and Candidate Species in the Action Area

Best Management Practice (BMP) and Mitigation Measures	NGS [1]	KMC	BM&LP Railroad	WTS	STS
Threatened, Endangered, and Sensitive Species					
TES-1. Prior to construction or maintenance actions, biologically sensitive areas identified by the U.S. Fish and Wildlife Service (USFWS) and relevant federal land managers in the Environmental Impact Statement (EIS), BA, and Biological Opinion (BO) would be marked or mapped by the operator and the appropriate measures would be implemented to avoid and/or minimize impacts to known populations of threatened, endangered, or sensitive species.		X	X	X	X
TES-2. Prior to right-of-way (ROW) vegetation treatments, ground-disturbing maintenance actions, or ground- disturbing maintenance actions to access roads, the segments of ROW or access roads where listed or sensitive plant species could occur would be surveyed and the locations marked or otherwise delineated to ensure treatments (herbicide, mowing, or hand clearing) or maintenance activities would avoid impacts to these species.		X	X	X	X
TES-3. Where suitable habitat for sensitive plants exists within the WTS or STS ROWs, vehicles would remain on existing roads while traveling through suitable habitat.			X	X	X
TES-4. Conduct annual wildlife monitoring for presence of federally listed species on the leased areas.		X			
TES-5. Fueling for vehicles and equipment would be prohibited within critical habitat for federally listed fish species.				X	X
TES-6. On national forest lands, APS will implement, as applicable on the STS, the Proposed Action, conservation measures, and reasonable and prudent measures as stipulated in the Phase II Utility Maintenance in Utility Corridors on Arizona Forests, July 17, 2008. [AESO/SE 22410- 2007-F-0365] to minimize impacts to applicable listed species and designated critical habitat.					X
General Operational Measures					
GM-1. Following completion of any construction activities, all tools, equipment, barricades, signs, surplus materials, debris, and rubbish would be removed from project work limits upon completion. Both NGS and KMC are industrial sites with construction part of daily operation.			X	X	X
Air Quality					
AQ-1. Routine maintenance, repair, and efficiency improvements to air pollution control systems at NGS plant.	X				

Table 1 Impact Avoidance and Minimization Measures Directly and Indirectly Applicable to Conservation of Federally Listed, Proposed, and Candidate Species in the Action Area

Best Management Practice (BMP) and Mitigation Measures	NGS [1]	KMC	BM&LP Railroad	WTS	STS
AQ-2. Ongoing maintenance of coal handling and fugitive dust suppression system at NGS plant and KMC would occur to minimize dust and control combustible coal dust particles.	X	X			
AQ-3. O&M of Glen Canyon air monitoring station and KMC monitoring stations.	X	X			
AQ-4. Vehicle access would be restricted to existing access roads and within ROW corridors.			X	X	X
AQ-5. Vehicles traveling off-road within the WTS and STS ROW would minimize impacts to the landscape and resources to the extent possible, by reducing travel speeds and minimizing the number of trips back and forth. A maximum vehicle speed of 25 miles per hour would be maintained; conditions often dictate much lower speeds.			X	X	X
Wildlife					
W-1. For routine vegetation maintenance (mechanical and hand clearing) and ground-disturbing maintenance activities, workers would watch for nesting birds. If an active nest is found, the vegetation containing the active nest would be avoided until after the nesting season. If the active nest is in vegetation that is causing a safety or system reliably risk, the operator would coordinate with the USFWS and the federal land manager to determine the appropriate removal procedures and ensure compliance with the Migratory Bird Treaty Act.	X	X	X	X	X
W-2. If nests are found on system infrastructure and nest removal or repair work is necessary, the operator (i.e., SRP, APS, NV Energy, Peabody Western Coal Company) would coordinate with the USFWS and the federal land manager to ensure compliance with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act, as appropriate.	X	X	X	X	X
W-3. Herbicide treatments BMPs: Between April 15 and August 15, the spray vehicle would watch for ground nesting birds. If any are seen, the operation would be stopped and the area would be completed utilizing handheld or backpack sprayers. • At any location where the vegetation density is sufficient to provide adequate cover for nest sites, for example dense stands riparian areas, the area to be treated would be surveyed by a qualified biologist for nests prior to spraying. If nests are found during the survey or encountered during the course of the application, spraying would cease and be postponed until after August 15 or until the nest is inactive. All vehicles would be operated in a safe and prudent manner, maintaining speeds of 15 to 20 miles per hour within the ROW.					X

Table 1 Impact Avoidance and Minimization Measures Directly and Indirectly Applicable to Conservation of Federally Listed, Proposed, and Candidate Species in the Action Area

Best Management Practice (BMP) and Mitigation Measures	NGS [1]	KMC	BM&LP Railroad	WTS	STS
W-4. As transmission and lower voltage powerlines are replaced and maintained, installed equipment would meet the most current Avian Powerline Interaction Committee design standards to prevent bird electrocutions.	X	X	X	X	X
W-5. Speed limits would be followed to minimize vehicular collisions with wildlife and decrease fugitive dust emissions.	X	X	X	X	X
W-6. Excavation sites would be monitored or covered to avoid trapping wildlife, and routes of escape for wildlife would be maintained. The construction site would be inspected daily for appropriate covering and flagging of excavation sites. Each morning the construction site would be inspected for wildlife trapped in excavation pits.	X	X	X	X	X
W-7. While working in riparian areas, workers would reduce the number of trips in and out, use hand crews if possible, minimize time spent working within the riparian area, and/or stage vehicles and materials outside riparian areas, if possible.			X	X	X

Table 1 Impact Avoidance and Minimization Measures Directly and Indirectly Applicable to Conservation of Federally Listed, Proposed, and Candidate Species in the Action Area

Best Management Practice (BMP) and Mitigation Measures	NGS [1]	KMC	BM&LP Railroad	WTS	STS
Vegetation Management					
VM-1. Herbicide treatments BMPs: All applicable labels, federal and state laws, and regulations with regard to the use and application of herbicides would be strictly adhered to. Crew members would consist of licensed herbicide applicators. All herbicide applications would be spot treatments utilizing backpack, handheld, and quad/all-terrain vehicle mounted sprayers with plant specific treatment. There would be no new roads or ground disturbing activities. If a portion of the transmission line is inaccessible by road or sensitive habitats occur within the ROW, the crew would drive to the nearest location and walk to the site with the necessary equipment. Crews would carry telephones, chemical spill kits, shovels, and emergency phone numbers with them.					X
VM-2. Vegetation management on WTS and STS systems and BM&LP Railroad: Vegetation management would not take place outside the ROW corridor. Existing roads would be used to access powerline ROWs. Where vehicle access is not available crews would hike in from the nearest access point. Existing roads within the powerline ROW would be used, where possible. Mowers would not be operated on slopes greater than 30 degrees.			X	X	X
VM-3. On BLM lands, per Implementation Powerline Corridor Management Plan for Vegetation Management on BLM lands (October 2, 2008): Saguaro treatment would be conducted in accordance with treatment protocols in the Amendment to APS Line Corridor Management Plan for Vegetation Management (April 2, 2009). APS would avoid impacts to agave plants where possible as described in the Corridor Management Plan.					X

Table 1 Impact Avoidance and Minimization Measures Directly and Indirectly Applicable to Conservation of Federally Listed, Proposed, and Candidate Species in the Action Area

Best Management Practice (BMP) and Mitigation Measures	NGS [1]	KMC	BM&LP Railroad	WTS	STS
VM-4. For corridor vegetation and line maintenance, fire restrictions would be reviewed and followed, and appropriate measure taken during periods of high fire risk: Contractors and utility workers would have one fire tool per person at the vegetation treatment site. Each truck would have one Indian Water Pump on-site. Mowers would have 500-gallon Water Tenders on-site. For STS, APS leadership personnel are red carded.			X	X	X
VM-5. Ensure that utility mower, track, or other off-road equipment, which has high potential to carry noxious weeds, are free of soil, weeds, vegetative matter, or other debris that could harbor seeds prior to initiating vegetation management and treatments.			X	X	X
Water Quality					
WQ-1. Rail cars at Coal Loading Station are filled below top to minimize spillage and exposure to wind. Observed spillage is cleaned up after the train leaves.			X		
WQ-2. Where applicable maintenance of a Spill Prevention, Control, and Countermeasures Plan that contains measures used to prevent oil discharges from occurring and actions for responding to a spill in an effective and timely manner to mitigate the impacts of any discharge to navigable water. Actions in the Spill Prevention, Control, and Countermeasures Plan include preventative maintenance of equipment and containment and discharge prevention systems; annual employee training; and monthly inspections.	X	X	X	X	X
WQ-3. Ongoing operation, maintenance, replacement and improvement of the systems would occur as needed to safely and efficiently store oil and chemicals.	X	X			
WQ-4. Implementation of the Groundwater Protection Plan and compliance with Coal Combustion Residual Rule would occur to ensure protection of N-Aquifer.	X				
WQ-5. To protect groundwater, hazardous fluid spill prevention and protection practices would be implemented.	X	X	X	X	X

Table 1 Impact Avoidance and Minimization Measures Directly and Indirectly Applicable to Conservation of Federally Listed, Proposed, and Candidate Species in the Action Area

Best Management Practice (BMP) and Mitigation Measures	NGS [1]	KMC	BM&LP Railroad	WTS	STS
WQ-6. During repairs and maintenance of project infrastructure, standard BMPs to prevent degradation of surface waters (i.e., spill prevention and capture plans, storm water runoff controls, silt fencing and straw bales, and sediment and erosion controls) would be implemented.	X	X	X	X	X
WQ-7. Staging areas for loading and unloading of equipment would be located in previously disturbed areas, but outside of floodplains and other wet areas. NGS and the RR are on previously disturbed industrial sites.		X		X	X
WQ-8. Maintenance activities around the Virgin River would be done without fording the river.				X	
WQ-9. Conduct a hydrologic water monitoring program. This includes quality and quantity of ground and surface water.		X			
Earth Resources: Soil Loss and Erosion					
ER-1. Construction and O&M activities would be scheduled as feasible to minimize work during periods when the soil is too wet to support construction equipment, which could cause deep ruts, road degradation, and surface disturbance.	X		X	X	X
ER-2. Driving support vehicles or quad/utility terrain vehicles in riparian areas would be avoided unless there is/are established road(s).			X	X	X
ER-3. If traffic control structures (e.g., boulders, barriers, dips) are moved, they would be returned to the original position/design when work is complete.			X	X	X
ER-4. Conduct a blasting monitoring program which monitors ground vibration and air overpressure. The mine uses electric blasting caps and noiseless detonating equipment to reduce air blast and noise.		X			
ER-5. Conducts ongoing vegetation mitigation, monitoring, and enhancement of reclaimed areas. Utilizing a revegetation plan to restore lands affects by mining operations to support livestock grazing, wildlife habitat and cultural plants.		X			

[1] Includes Navajo Generating Station (NGS) and associated facilities, except for the BM&LP Railroad.

NGS = Navajo Generating Station; KMC = Kayenta Mine Complex; BM&LP = Black Mesa & Lake Powell.

1.3 Species-Specific Conservation Measures

1.3.1 Fish Species

In addition to the general measures listed in **Table 1**, a number of species-specific conservation measures have been identified in the Navajo Project Operation and Maintenance Plan (SRP 2016) and others have been developed during preparation of this BA. Conservation measures for federally listed fish species and their critical habitat at potential risk from baseline mercury and selenium concentrations in the Colorado River below Glen Canyon Dam and in the San Juan River have been developed through interagency coordination. NGS emissions resulting from the Proposed Action would contribute very small amounts of mercury and selenium to baseline conditions. The ESA Consultation Handbook, Interagency Cooperation Regulations 50 Code of Federal Regulations Part 402 and ESA, 1998 defines conservation measures as “actions to benefit or promote the recovery of listed species that are included by the federal agency as an integral part of the Proposed Action. These actions will be taken by the federal agency or applicant and serve to minimize or compensate for project effects on the species under review.” The purpose of a conservation measure is to avoid, reduce, or compensate for adverse effects to federally listed species or to benefit protected species and their critical habitat. Effects monitoring, conservation measures, and science-based decision-making would be part of an overall conservation approach for the Proposed Action.

The USFWS, National Park Service (NPS), Arizona Game and Fish Department (AGFD), U.S. Geological Survey (USGS), Hopi Tribe, Navajo Nation Department of Fish and Wildlife, SRP, and U.S. Bureau of Reclamation (Reclamation) have been involved in the development process and will continue to be involved in the implementation of conservation measures. All agencies favor a plan that commits to conservation measures that are specific and the implementation and effectiveness of which will be verified, while allowing for flexibility within these parameters. The NPS produced a Comprehensive Fisheries Management Plan for the Grand Canyon National Park and the Glen Canyon National Recreation Area in Coconino County, Arizona published December 9, 2013. The NGS-KMC Project has incorporated (and modified with input from the NPS) some of the conservation measures from this NPS adaptive management plan, and the measures have been thoroughly evaluated in cooperation with AGFD and USFWS.

Reclamation would be responsible for implementing ongoing conservation measures for affected fish species (Colorado pikeminnow, humpback chub, and razorback sucker), with input from a science-based team (Science Team) to coordinate recovery efforts within the action area. The Science Team would be made up of fishery biologists from the USFWS, Reclamation, USGS, NPS, AGFD, New Mexico Department of Game and Fish, Utah Division of Wildlife Resources, Nevada Division of Wildlife, SRP, Hopi Tribe, and Navajo Nation Department of Fish and Wildlife, should they accept the invitation to participate. It is anticipated that Reclamation would develop a Memorandum of Understanding with team members, which would guide implementation.

The Reclamation Team Lead would ensure that the Science Team would meet at least annually to: 1) evaluate and discuss the annual reports and conservation measure implementation; 2) review monitoring data provided by the various agencies; and 3) make recommendations to Reclamation regarding implementation and modifications to the monitoring and conservation measures. The Reclamation Team Lead will ensure that reporting requirements to USFWS are met. Reclamation, with the assistance of the Science Team, would be responsible for coordinating the implementation of the various conservation measures with the San Juan River Recovery Implementation Program, Grand Canyon National Park, and the Lake Mead Workgroup.

The conservation approach would require Reclamation and the applicants to undertake specific, concrete conservation and monitoring measures that are reasonably specific, certain to occur, capable of implementation, and subject to deadlines or otherwise enforceable obligations, as outlined below. These measures would support the following objectives in the action area:

1. Provide funding to implement conservation measures that demonstrably offset project impacts and enhance recovery for the affected listed fish species and their habitat;
2. Support periodic water quality and fish tissue sampling efforts with a focus on mercury and selenium to evaluate the effects on razorback sucker, and humpback chub, and Colorado pikeminnow.

By 2020, the funding necessary to implement the conservation measures would be placed in a nonwasting account managed by SRP, on behalf of the NGS Participants, and would be available to fund the conservation projects and monitoring at the direction of Reclamation with input from the Science Team. The following monitoring and conservation measures would be implemented for the NGS-KMC Project for the purpose of compensating for or offsetting the potential adverse effects of mercury and selenium deposition on federally listed fish species and their critical habitat. The Science Team's goal is to ensure accountability for the outcome of the conservation efforts to achieve defensible goals and transparent objectives. As described above, the NGS Participants would be responsible for providing sufficient funds for implementation of the conservation measures. The available funding would be applied to conservation measures that directly benefit the species. The structure and management of the fund would be defined as the conservation approach is finalized.

Should any of the following conservation measures (FS-1 through FS-5, and MM-1) be determined ineffective based on new technology or other data, Reclamation in coordination with the USFWS will evaluate the potential for adjusting or diverting funds from that conservation measure to a different measures (e.g., move funds from FS-3 to FS-4) or to a comparable recovery effort. Any funds diverted to new recovery efforts will fit within the scope and intent of this BA.

Section 7 compliance also requires monitoring of impacts caused by the project if incidental take is anticipated. Monitoring would ensure that the actual impacts are at or below the levels anticipated and covered in the consultation. For this reason, Monitoring Measure 1 (MM1) is included, as described below, and includes monitoring of metal concentrations in water and fish tissue. In addition to MM1, NGS would report the annual emission rates of mercury and other metals to the Science Team to ensure that the modeled concentrations used in the Ecological Risk Assessments (ERAs) are within the range used to determine project-related emissions effects on listed species.

1.3.1.1 Colorado Pikeminnow, Humpback Chub, and Razorback Sucker

FS-1: Non-native Fish Management in the Colorado River Grand Canyon Area

Goals: The objective of this measure is to finance projects which offset project-related impacts to humpback chub and razorback sucker by monitoring and removing nonnative fish within the action area. This measure will reduce adverse biological impacts of competitive and predatory nonnative fish on populations of listed fish species.

Conservation Need: Nonnative fish negatively impact populations of endangered humpback chub and razorback sucker within the action area through predation and competition. For example, in 2015, AGFD discovered green sunfish in the slough below Glen Canyon Dam. These sunfish may have been reproducing. The AGFD alerted the Grand Canyon National Park and Glen Canyon National Recreation Area of the presence of the sunfish. Despite a quick response time by the NPS staff, green sunfish were able to move elsewhere within the slough and potentially further downstream. The measure would ensure a rapid response to nonnative fish detections within the action area to prevent nonnative fish escapement to other riverine habitats. AGFD, USFWS and NPS currently monitor the Colorado River below Glen Canyon Dam, and the USFWS monitors critical areas of the watershed (e.g., Little Colorado River) that act as a conduit or source for nonnative fish. These agencies could provide a rapid response, dependent on availability of staff and materials.

Implementation: Reclamation would provide funds to augment detection monitoring for nonnative species, conducted by USGS, NPS, AGFD, and USFWS, and to ensure availability of materials to those agencies engaged in nonnative fish removal. Funds will be provided to agencies annually (or asneeded for rapid responses) for the purchase of chemicals, nets, and other equipment. Field implementation of nonnative fish removal will be as needed in response to detections.

FS-2: Razorback Sucker Translocations

Goals: The objective of this measure is to augment razorback sucker numbers in the Grand Canyon portion of the Colorado River through translocations, if the NPS and USFWS determine the species needs augmentation. If translocations are determined by NPS and USFWS to be needed, this measure will offset project-related impacts to razorback sucker by increasing razorback sucker numbers in the Grand Canyon.

Conservation Need: Recruitment of razorback sucker in the lower Grand Canyon appears to be limited, despite the presence of larvae in 2014 and 2015. Factors limiting recruitment are uncertain. Reclamation funded a review and summary of razorback sucker habitat in the Colorado River System in 2012. This summary presents a preliminary evaluation of potential razorback sucker habitat in the lower Grand Canyon. The study identifies the complex habitat that razorback suckers require, such as backwaters, islands and percent vegetation cover that was a deciding factor for NPS to consider a translocation effort (Valdez et al. 2012). This conservation measure would support two potential outcomes for razorback sucker in the Grand Canyon portion of the Colorado River, as discussed in the NPS Comprehensive Fisheries Management Plan (NPS 2013): RBS2, which states that *razorback sucker are present in substantial numbers in the Colorado River Fish Management Zones, but are not reproducing*; and RBS3 stating that *suitable razorback sucker habitat is available, but few individuals are present and no reproduction.*

Implementation: Reclamation and the Science Team will coordinate with the Lower Colorado River Multi-species Conservation Program (LCR MSCP), USFWS, and NPS regarding any proposed translocation effort. Translocation efforts will be determined by an NPS assessment of the availability of suitable habitat for razorback sucker in the action area. If NPS and USFWS determine that the razorback sucker needs augmentation, then the Science Team will support that effort by assisting in the capture, rearing, stocking, translocation or augmentation as appropriate for the species. If NPS and the USFWS determine that the canyon habitat is unsuitable for razorback sucker, then no translocations would occur, FS-2 would not be implemented, and funds would be diverted to FS-1 to further augment nonnative fish removal. As a result of this scenario, listed fish species will continue to benefit from nonnative fish removal under FS-1.

FS-2 will use wild spawned larvae which are currently being raised in ponds. In addition to using wild-spawned larvae, larval fish could be collected from Lake Mead and other areas and then Passive Integrated Transponder (PIT)-tagged and released at a tributary mouth or mainstem portion of the Colorado River or the Lake Mead inflow area.

The estimated cost for this measure is $75,000 per year to cover capturing of larvae, rearing fish in ponds, harvesting fish for stocking, transporting fish to stocking locations, and additional monitoring of fish (radio- and PIT-tagging). Reclamation, in coordination with NPS and the Science Team, will determine through monitoring if translocations should continue, for how long and if this is succeeding, or be discontinued. Implementation of these activities will be conducted in close coordination with the USFWS.

FS-3: Support Activities at the USFWS Southwest Native Aquatics Research and Recovery Center (SNARRC formerly known as the Dexter Fish Hatchery)

Goals: The objective of this measure is to provide financial support to SNARRC for the purpose of augmenting the genetic diversity of the four federally listed Colorado River fish species. Funding to support SNARRC's activities will be used to support research, propagation, and conservation activities for all of these species. This measure will offset project-related impacts to razorback sucker, Colorado pikeminnow, and bonytail by improving the genetic diversity of the broodstock and numbers of these fish that will be available for stocking efforts in the San Juan River and potentially other areas to support the general species recovery.

Conservation Need: Effects from mercury deposition impact all life stages of fish, from larvae to adults. Effects range from reduced fecundity to disruption of various physiological processes. While the effects of mercury have been found to be more prevalent in fish species that feed at the top of the food chain, all species may be impacted from increased mercury loading. Increasing the number of fish in an aquatic system through rearing and stocking is one of the primary methods that is used to conserve and recover endangered fish populations in the Colorado River Basin, including within the action area. The USFWS SNARRC has been conducting research and propagation efforts for all four of the Colorado River endangered fish for decades. SNARRC has all four species on station and is actively propagating razorback sucker, Colorado pikeminnow, and bonytail for various recovery programs. While SNARRC is not engaged in active propagation activities for humpback chub, it is the only refuge population in the world for these fish species.

Implementation: SNARRC has identified a need to bring in more Colorado pikeminnow broodstock from the Upper Colorado River, from known locations, to augment genetic diversity of the fish. They also have identified a need to do genetics work on any new broodstock and existing fish. This measure will involve funding fish collection and genetic analysis in producing genetically healthy fish for their stocking program in the San Juan River. The benefit of this measure is to ensure a more diverse and robust genetic stock, thereby providing for higher survival rates in the wild population (Furr 2010; Ryden 2005).

The estimated cost for this measure would be $50,000 to $100,000 in the initial year to cover fish collection and genetics work. Reclamation, with input from the Science Team, would determine if the goal in FS-3 is met or if additional efforts are needed over the life of the action.

FS-4: Support Transport of Colorado Pikeminnow and Razorback Sucker above the Waterfall Barrier in the San Juan River

Goals: The objective of this measure is to provide financial support to capture and transport Colorado pikeminnow and razorback sucker upstream of a waterfall barrier in the San Juan River arm of Lake Powell to allow the fish access to habitat in the San Juan River. Funding to support the capture and transportation of these fish around this barrier would offset the effects of mercury and selenium by increasing the number of potentially spawning fish in the San Juan River and serve as a mechanism to connect the river and lake below the waterfall with fish and habitat in the river upstream of the barrier.

Conservation Need: For over 20 years a large waterfall (about 30 feet high) has existed in the San Juan River near Paiute Farms, Utah, where the river enters Lake Powell. The waterfall is present when Lake Powell reservoir elevations are below 3,660 feet, which has been continuous since 2000, except for a 1-month period in 2011. This waterfall serves as a barrier to movement for all fish species. While the waterfall effectively keeps nonnative fish from moving upriver, it also prevents native fish, especially Colorado pikeminnow and razorback sucker, from moving back upstream after they have drifted over the waterfall as larvae, juveniles, or adults. Ryden and Ahlm (1996) identified this barrier as a major impediment to migrating fish. In the spring of 2015, crews sampled below the waterfall on several occasions and encountered numerous endangered fishes, as described in the *Fiscal Year 2016 Annual Budget and Work Plan* for San Juan River Recovery Implementation Program (USFWS 2016). One trip captured four untagged razorback suckers immediately below the waterfall via castnets (Cheek, unpublished data cited in Utah Division of Water Resources [2015]). A second trip deployed submersible and floating PIT-tag antennae and detected 338 individual fish, which included 319 razorback sucker, one bonytail, one Colorado pikeminnow, and 19 unidentified tags (Cathcart et al., unpublished data cited in Utah Division of Water Resources [2015]).

In the spring of 2016 a one-time pilot program was conducted by Reclamation to relocate Colorado pikeminnow and razorback sucker over the waterfall using buckets to move PIT-tagged fish. Approximately 170 razorback sucker and 4 Colorado pikeminnow were collected and transported from this effort. Mobilizing equipment below the falls and moving the fish directly above the falls resulted in no fish mortality and less overall cost (McKinstry et al. 2016).

A fish ladder at the waterfall on NPS land was considered but the site was determined to be unsuitable due to a shifting river bed, lake level variability, high velocity flows, and accessibility. A fish ladder also would allow predatory nonnative fish from Lake Powell to move up into the San Juan River.

Implementation: This measure will provide funding to continue capture and transport of Colorado pikeminnow and razorback sucker upstream of a waterfall that blocks fish movement in the San Juan River. This measure will be implemented three times a year in March, April and June, for a minimum of three years after 2019. Implementation of this measure will continue if determined to be appropriate by Reclamation with input from the Science Team. Effectiveness of this measure will be based largely on numbers of fish translocated above the falls which will therefore be provided the opportunity to seek out adequate habitat for a spawning in the river. The estimated cost for this measure is approximately $50,000 per year to cover trapping and netting fish at the waterfall, and holding PIT- and radio-tagged fish prior to transport around the waterfall three times per year.

FS-5: Funding Support for Habitat Improvements in the San Juan River

Goals: The objective of this measure is to provide funding to improve and provide habitat for Colorado pikeminnow and razorback sucker in the San Juan River, which would be used for nursery or recruitment areas for these species. This measure will offset project-related impacts to Colorado pikeminnow and razorback sucker by providing habitat that currently is limited in the San Juan River, which will improve species recruitment, and by augmenting the physical habitat element of critical habitat for the species.

Conservation Need: The channel of the San Juan River has become incised and channelized from the following: 1) reductions in high flows due to construction and operation of Navajo Dam; and 2) the introduction and almost complete coverage of the riparian area with nonnative Russian olive *(Elaeagnus angustifolia)*. The Russian olive prevents higher flows from reworking the channel and reduces complexity along the channel margins. Furthermore, this non-native vegetation armors the bank and prevents the development of native vegetation. Due largely to these conditions, complex habitats such as secondary channels and backwaters, which are important to early life stages of native fish, are limited within the San Juan River.

Ecological restoration of the San Juan River has been ongoing since 2009. Phase 1 of this effort, known as *The San Juan River RERI Project,* was completed in 2013; Phase 2 was completed in 2015. The Nature Conservancy has managed and coordinated the effort with government agencies and the Navajo Nation on water flow management, restoring secondary channels and backwaters and removing nonnative fish and vegetation (McKinstry 2016). Agencies provide input on specific site selection and design of the habitats through the San Juan River Recovery Implementation Program. Fish biologists from the New Mexico Department of Game and Fish and The Nature Conservancy are monitoring the Phase II restoration site for wild-spawned razorback suckers and Colorado pikeminnow, and have a remote PIT Tag antenna at the outflow of the restored channel. They have been detecting about 30 larval Colorado pikeminnow each year since the restoration was completed. In 2015, the remote antenna detected 300 individual pikeminnow and razorback suckers using the restored site (Zeigler 2016).

Implementation: This conservation measure will provide funding so that the habitat improvement effort could be continued after Phase 2 of the current program. Study locations and methods for the habitat improvement work will be based on previous restoration efforts in the San Juan River, as described in Bliesner et al. (2007). A three-step process will be followed to identify sites for constructing backwater areas. The initial step will involve screening of potential sites to meet the following criteria: 1) capable of providing stable site with flows ranging from 500 to 1,550 cubic feet per second; 2) external, controllable water source for flushing sediment; 3) accessible to stocking trucks; and 4) reasonable probability of land-owner permission for construction. The next step will be to conduct a field investigation of the potential sites to confirm that site criteria can be met. The last step in the site selection will be to conduct an evaluation of the potential sites for a ranking to meet site criteria and costs. After the site is selected, the restoration project will be constructed following previous methods used in the Phase 1 and Phase 2 work.

Approximately $50,000 per year would be set aside and made available to The Nature Conservancy to conduct habitat restoration for Colorado pikeminnow and razorback sucker. The average cost for channel restoration is approximately $25 per linear foot, and the $50,000 would produce 1,500 to 2,000 linear feet of habitat. This funding could contribute to other planned side-channel creation projects.

MM-1: Monitoring Measure-1:

Goals: The objective of this measure is to support periodic water quality and fish tissue sampling efforts with a focus on mercury and selenium in the Colorado River downstream of Glen Canyon Dam, and sampling, when necessary, in the San Juan River from approximately Farmington to Lake Powell. The ERAs and the rationale for quantifying impacts to listed fish are based on projected future water column and fish tissue concentrations of mercury and selenium in the action area. The sampling will provide data to determine if the total concentrations of these chemicals are within the modeled range and thus the impacts (project-related and cumulative) are not greater than those addressed in this BA.

Background and Need: The Gap Region ERA used literature-derived mercury and selenium concentrations in the analysis of potential risk to federally listed fish species in the Colorado River below the Glen Canyon Dam in the Grand Canyon. Several key studies were considered for obtaining fish tissue data used in the Gap Region ERA associated with the Southwest Gap Region, including Walters et al. 2015, Eagle-Smith et al. 2014 and Kepner 1988. Of these studies, the recent fish tissue results reported in Walters et al. (2015) were found to drive the majority of the ecological risk to federally listed species in the Gap Regions ERA based on comparison of whole body fish tissue concentrations to applicable critical body residues. The other data sources generally reported lower tissue concentrations and resulting risk estimates for the same fish species. For example, recent tissue data from Eagles-Smith et al. (2014) show lower tissue concentrations for rainbow trout than those reported in Walters et al. (2015) consistent with previous studies (Ramboll Environ 2016c), which suggests a lower level risk to non-native fish species such as rainbow trout. The Gap Regions ERA concluded that based on the Walters et al. data, risk to listed fish species is possible in the Southwest Gap area but also emphasize that risk estimates based on these data likely overestimate risk. The disparity in tissue levels reported by Walters et al. (2015) and previous studies suggest that monitoring of fish tissue and/or water concentrations may be warranted.

For the San Juan River ERA, fish tissue concentrations were obtained from exposure modelling (using surface water concentrations and water-to-fish bioconcentration factors) and tissue data were obtained from a limited dataset available from USFWS sources (Simpson and Lusk 1999, and unpublished data from Osmundsun and Lusk 2010). The latter source offered data from recently stocked fish, which may not be representative of in stream conditions. The general lack of fish tissue data in the San Juan River suggests that monitoring of fish tissue and/or water concentrations may be warranted.

The results of fish tissue and surface water monitoring will be used to compare against the modeling results and impact assumptions used to determine impacts to listed fish and to ensure that the level of mercury and selenium are not greater than that analyzed in this BA. This information will be combined with the reporting of annual mercury, selenium, and other emissions from NGS to ensure that the estimates of impacts to the listed species and their critical habitats are within the range estimated in this BA.

Implementation: Periodic water column and fish tissue sampling would be performed as determined necessary by Reclamation, with input from the Science Team. Sampling would be conducted if other programs and efforts are not collecting the appropriate mercury and selenium water and fish tissue concentrations in the action area to be able to assess if the modeled concentrations are within the predicted range. In addition, while moving razorback sucker and Colorado pikeminnow over the waterfall (see FS-4 above), biologists may collect a sample of eggs and tissue to test for mercury and selenium concentrations.

Reclamation anticipates working with agencies such as the AGFD, Arizona Department of Environmental Quality/Water Quality Division, Utah Division of Water Resources, NMDGF, USGS, NPS, and USFWS to monitor the modeling assumptions that were used in the project ERAs. An implementation plan would be developed with the partnering agencies, which would describe sampling locations, sample collection and analytical methodologies, use of surrogate fish species for the listed fish species, reporting, and how resulting data would be compared to the concentrations used and estimated in the project ERAs. The cost estimate is approximately $50,000 in any year monitoring is conducted. Reclamation with input from the Science Team, would determine the frequency and number of future sampling efforts, based on the results of the first effort.

1.3.1.2 Loach Minnow, Spikedace, Gila Topminnow, and Gila Chub

For other federally listed fish species and their critical habitat, conservation measures would apply to the STS. On National Forest Lands, APS would implement, as applicable on the STS, the Proposed Action, conservation measures, and reasonable and prudent measures as stipulated in the Phase II Utility Maintenance in Utility Corridors on Arizona Forests, July 17, 2008. [AESO/SE 22410- 2007-F-0365] to minimize impacts to the six species (Colorado pikeminnow, Gila topminnow, Gila chub, loach minnow, spikedace, and razorback sucker) and designated critical habitat. All of these species have designated critical habitat within the STS portion of the action area except Colorado pikeminnow and Gila topminnow. APS and SRP are currently preparing a BA that includes herbicide treatment on the power lines covered by the Phase II consultation. The new BO, once completed, will supercede the 2008 BO for APS and SRP.

The following conservation measures will be implemented in critical habitat for loach minnow and spikedace:

- The timing of crews pruning or removing trees would be coordinated such that work would be consolidated with other work in such a way that results in the least number of low water crossings.
- When possible, crews would walk over low water crossings rather than drive if the distance to the vegetation or line maintenance treatment is close enough that operations would not be hindered.
- Transport of crews would occur in the least number of vehicles possible just as long as the safety of crews is not hindered.
- As long as the safety of crews is not compromised, vehicle speeds would be slowed in stream crossings.

- No landings for refueling or staging would be allowed within a 0.25-mile of loach minnow critical habitat.
- Low water crossings would not be used in the Upper Verde River.

1.3.2 Avian Species

AS-1: Mexican Spotted Owl. The following measures would avoid impacts to this species and avoid or minimize impacts to its habitat associated with mining of new coal resource areas in the northeast portion of the proposed KMC permit area:

- Prior to implementing mining activities within 2 miles of suitable coniferous forest/canyon habitat, conduct protocol surveys for Mexican spotted owl.
- If Mexican spotted owls are determined to be nesting within the survey area, suspend surface-disturbing activities within 0.25 mile of PAC boundaries between March 1 and August 31.

AS-2: Southwestern Willow Flycatcher. The following measures, adapted from the Phase II Utility Maintenance in Utility Corridors on Arizona Forests, July 17, 2008 [AESO/SE 22410- 2007-F-0365], would avoid impacts to this species and avoid or minimize impacts to its habitat associated with O&M activities along the WTS and STS:

- Avoid ground work disturbance in the floodplain containing occupied breeding habitat between May 1 and August 30.
- For aerial patrols and inspections, transmission line operators and contractors thereof would not land the helicopter for refueling within 0.25 mile of southwestern willow flycatcher occupied habitat during the breeding season.

AS-3: Western Yellow-billed Cuckoo. The following measures, adapted from the Phase II Utility Maintenance in Utility Corridors on Arizona Forests, July 17, 2008 [AESO/SE 22410- 2007-F-0365], would avoid impacts to this species and avoid or minimize impacts to its habitat associated with O&M activities along the WTS and STS:

- Avoid ground work disturbance in the floodplain containing occupied breeding habitat between June 1 and August 30.
- For aerial patrols and inspections, transmission line operators and contractors would not land the helicopter for refueling within 0.25 mile of western yellow-billed cuckoo occupied habitat during the breeding season.

1.3.3 Reptile Species

RS-1: Mojave Desert Tortoise. To avoid and minimize impacts to the Mojave desert tortoise and its habitat, the WTS Operator would coordinate with Reclamation and USFWS and, as appropriate, other federal and state land and wildlife management agencies and local government jurisdictions to implement conservation measures during O&M (including transmission infrastructure repair) activities in suitable desert tortoise habitat along the WTS. Depending on the timing (i.e., desert tortoise active vs. inactive season) and the nature and level of disturbance associated with specific O&M activities, these measures would include the following:

1. The WTS Operator would designate a company Field Contact Representative (FCR) to ensure compliance with the biological stipulations as stated in the federal ROW permits, the terms and conditions of the BO issued for this project, and other applicable requirements. The duties of the FCR include the following:
    a. Complete a desert tortoise education program prior to training employees and contractors.

b. Develop an employee and contractor environmental awareness program that would be approved by the USFWS and would cover such topics as desert tortoise distribution within the project area, general behavior and ecology, sensitivity to human activities, legal protection, penalties for violation (ESA), conservation and protection measures, reporting requirements, fire prevention, etc.

c. Train all internal and contractor staff prior to conducting O&M activities in suitable habitat for Mojave desert tortoise.

d. Coordinate with the USFWS regarding the approval and appropriate number of authorized biologists to be assigned on project- or maintenance-related activities. Authorized Biologists must be approved by the USFWS.

e. Maintain a training log (date and attendees) and submit this log as part of the annual reporting to Reclamation and USFWS.

2. To limit the potential for predation of desert tortoise by ravens, the WTS Operator shall implement the following measures:

   a. During any O&M activities, baseline nesting bird information will be recorded. This information would include stick nest locations, tower numbers, and notation of nesting species if possible. The Operator or an on-site biologist will conduct follow-up monitoring to determine if juvenile tortoise carcasses or bones are located under stick nests and report this information to the USFWS within 3 calendar days. This includes reporting known active raven nests (containing eggs or nestlings) so USFWS can coordinate removal. Inactive raven nests (no eggs or nestlings) may be removed at any time.

   b. To limit the potential for predation of desert tortoise by ravens, coyotes, feral dogs, and other opportunistic predators, the Operator would require all O&M waste to be contained and removed from the project area in a manner that does not attract ravens to the project area. All trash and food items would be placed in raven-proof containers and removed daily.

3. The following measures would apply to all O&M activities in Mojave desert tortoise habitat:

   a. Prior to daily O&M field activities, the Operator's on-site O&M supervisor would review the tortoise conservation measures with crews, log the meeting and attendees, and provide the log to the FCR at the end of the job.

   b. Project activities outside of fenced facilities will be scheduled between November 1 and February 28, as feasible.

   c. O&M excavations greater than 1 foot-deep will be fenced, covered, or filled at the end of each working day, or have escape ramps (1:1 slope) provided to prevent the entrapment of wildlife. Trenches and holes will be inspected for entrapped wildlife before being filled. Any entrapped animals will be allowed to escape voluntarily before O&M activities resume, or they may be removed by qualified personnel with an appropriate handling permit, if necessary.

   d. Any pipe, culvert, or similar structure with a diameter greater than 3 inches left aboveground on the work site for one or more nights would be inspected for tortoises before the material is moved, buried, or capped. As an alternative, all structures may be capped before being stored on the site.

   e. Vehicle traffic will be restricted to designated access routes and the immediate vicinity of O&M sites. Vehicle speeds will not exceed 25 miles per hour on access and maintenance roads and 20 miles per hour on unimproved access routes. Vehicles and equipment will be parked on pavement, existing roads, and previously disturbed areas, to the maximum extent feasible. Off-road travel in suitable habitat will be prohibited.

f. No pets (except service animals) will be permitted at work sites.

g. Prior to starting operations each day in work areas which are not totally enclosed by tortoise-proof fencing and cattle guards, the Operator's on-site Supervisor and any contract personnel shall be responsible for conducting a desert tortoise inspection in coordination with the authorized biologist or biological monitor, if present (see #4 and #5, below), using techniques approved by the USFWS. The inspection will determine if any desert tortoises are present in the following locations:

i. around and under all equipment;

ii. in and around all routes of ingress and egress; and

iii. in and around all other areas where the operation might expand to during that day.

If a tortoise is discovered during this inspection or later in the day, the Operator will immediately cease all operations in the immediate vicinity of the tortoise and will immediately notify the FCR or on-site biologist, if present.

h. Desert tortoise mortalities or injuries that occur as a result of project- or maintenance-related actions will be reported immediately to the FCR and USFWS, who will instruct O&M personnel on the appropriate action. The phone number for the FCR or USFWS point of contact will be provided to maintenance supervisors and to the appropriate agencies.

4. For O&M activities which do not result in substantial ground-disturbance, as determined by the FCR, the following measures will apply, in addition to #3, above:

a. For all non-patrol project activities occurring during the tortoise activity season (March 1 to October 31), a qualified biologist shall conduct preconstruction surveys for Mojave desert tortoise in suitable habitat. The biologist shall survey all work areas, including staging/laydown areas and access routes. Tortoise burrows and other sensitive features identified during the pre-construction survey shall be flagged and monitored, as determined by the FCR. If tortoises are found in the work area, activities will be modified to avoid injury or harm.

b. For all non-patrol project activities, a qualified biologist shall be present for all project activities occurring in designated critical habitat for Mojave desert tortoise. The biological monitor shall conduct pre-construction surveys for Mojave desert tortoise in suitable habitat. The biologist shall survey all work areas, including staging/laydown areas and access routes. Tortoise burrows and other sensitive features identified during the preconstruction survey shall be flagged and monitored by the biologist for avoidance.

5. For O&M activities which result in substantial ground-disturbance as determined by the FCR, the following measures will apply, in addition to #3, above:

a. An authorized desert tortoise biologist will be on-site during all ground-disturbing project activities in suitable habitat during the active desert tortoise season (March to October). At other times, a qualified biologist may be present in place of an authorized biologist. The biologist(s) shall conduct pre-construction surveys for Mojave desert tortoise in suitable habitat. The biologist(s) shall survey all work areas, including staging/laydown areas and access routes. Tortoise burrows and other sensitive features identified during the pre-construction survey shall be flagged and monitored by the biologist for avoidance.

b. Tortoises discovered to be in imminent danger during project activities may only be moved out of harm's way by an authorized desert tortoise biologist and following the terms of any concurrence or biological opinion issued by the USFWS for the work. Desert tortoises shall be handled only by qualified individuals following recognized protocol (USFWS 2009a, or current revisions).

c. Overnight parking and storage of equipment and materials, including stockpiling, will occur in previously-disturbed areas or areas to be disturbed that have been cleared by a qualified desert tortoise biologist. If not possible, areas for overnight parking and storage of equipment will be designated by the FCR based on recommendations of a qualified desert tortoise biologist.

d. An authorized biologist shall be present for road grading activities in designated critical habitat for Mojave desert tortoise during the tortoise activity season (March 1 to October 31); a qualified biologist may be present at other times of the year. The biological monitor shall conduct pre-construction surveys for Mojave desert tortoise in suitable habitat. The biologist shall survey all work areas, including staging/laydown areas and access routes. Tortoise burrows and other sensitive features identified during the pre-construction survey shall be flagged and monitored by the biologist for avoidance.

e. Water or other substances used as dust suppressants in designated critical habitat for Mojave desert tortoise shall not be allowed to pool.

6. The use of herbicides within USFWS-designated critical habitat, areas of critical environmental concern, and suitable desert tortoise habitat would be prohibited without prior approval from the USFWS and applicable land management agencies.

7. The FCR shall submit annual and reports for O&M activities that result in ground disturbance or require the presence of an authorized biologist or monitor. The annual report shall be submitted to Reclamation and the USFWS. Annual reports would document O&M activities that required monitors; numbers and locations of desert tortoises encountered; all instances of tortoise take resulting from harassment, harm, injury, or mortality; their disposition; effectiveness of protective measures; practicality of protective measures; recommendations for future measures that allow for better protection or more workable implementation; and the number of acres where vegetation is cleared and/or soil is disturbed. Annual reports would cover the calendar year and are due February 15 of the following year (e.g., the annual report for calendar year 2020 is due February 15, 2021).

8. Any deaths and injuries of desert tortoises would be investigated as thoroughly as possible to determine the cause. For any Mojave desert tortoise fatalities in Nevada, the wildlife staff of the USFWS Las Vegas Field Office (702-515-5230) and applicable land-managing agencies must be verbally informed of desert tortoise injuries or death immediately and within 5 business days in writing (electronic mail is sufficient). For any Mojave desert tortoise fatalities in Arizona, Law Enforcement Office (505-248-7889) and Arizona Ecological Services Office (602-242-0210) must be notified within 3 working days. The FCR or other authorized biologist would complete a Desert Tortoise Handling and Take Report.

9. Emergency Repairs: for emergency repairs beyond those typical O&M activities described as part of the Proposed Action, the WTS Operator would notify the local USFWS office and appropriate federal or state land management agency within 48 hours to determine appropriate follow-up actions.

RS-2: Sonoran Desert Tortoise. To avoid or minimize impacts to the Sonoran desert tortoise and its habitat, the STS Operator would coordinate with Reclamation, USFWS, BLM, other applicable federal and state land and wildlife management agencies as appropriate to implement conservation measures during transmission line O&M (including repair) activities in suitable Sonoran desert tortoise habitat along the STS. Depending on the nature and level of disturbance associated with specific O&M activities, the STS Operator would implement the following actions:

1. Designate a company FCR to ensure compliance with these conservation measures, biological stipulations stated in the federal ROW permits, and other applicable requirements.

2. Develop a training and awareness program for all O&M personnel and contractors. Training would be conducted by the FCR or a qualified contractor annually for employees conducting O&M and for contractors prior to initiating work.

3. Provide detailed instruction to all crews with regard to proper and legal tortoise handling and relocation protocols. Provide disposable gloves to minimize risk of spreading Upper Respiratory Tract Disease and other transmissible diseases from tortoise to tortoise.

4. Document all known Sonoran desert tortoise injuries and mortalities from STS Operator's O&M activities, and record in a central database. As part of the annual training program, conduct a root cause analysis of these mortalities with recommendations from field staff to minimize.

5. Cover any holes augured for vertical structure replacement if left unattended, and inspect for trapped animals prior to filling the holes.

6. Use trained field supervisors and linemen to implement proper monitoring techniques including searching for and inspection of potential burrows within work areas prior to implementing authorized repair activities, including prior to clearing of vegetation. Develop standard clearance protocol and documentation standards. FCR or qualified contractor staff would conduct field audits of clearance activities to ensure compliance and adequacy of inspections. Field audits would be conducted on 10 percent of all work conducted in high and medium value habitat as identified by the USFWS (2015j).

7. During the annual refresher training, provide all attendees a rearview mirror placard for placement in all O&M vehicles to remind workers to check under vehicles and around work areas for tortoises prior to moving vehicles.

8. Develop a database within the STS Operator geographic information system, including records of Sonoran desert tortoises killed, injured, handled to move from harm's way, or detected, and tortoise shelters identified within the STS ROW during O&M activities. This database would be used by the FCR to identify hot spots and areas of special concern that may need more focused conservation awareness.

9. To reduce impacts to suitable habitat, the FCR would coordinate with the O&M project managers to minimize the work area needed repair of infrastructure or repair of unpaved access roads occurring within suitable habitat for the Sonoran desert tortoise. To the maximum extent practical and safe, repair crews would use existing disturbed areas for O&M activities. Because of the disturbance associated with initial construction of the line and ongoing routine vegetation maintenance activities, in most cases during infrastructure maintenance activities, very limited vegetation clearing would be required.

This page intentionally left blank